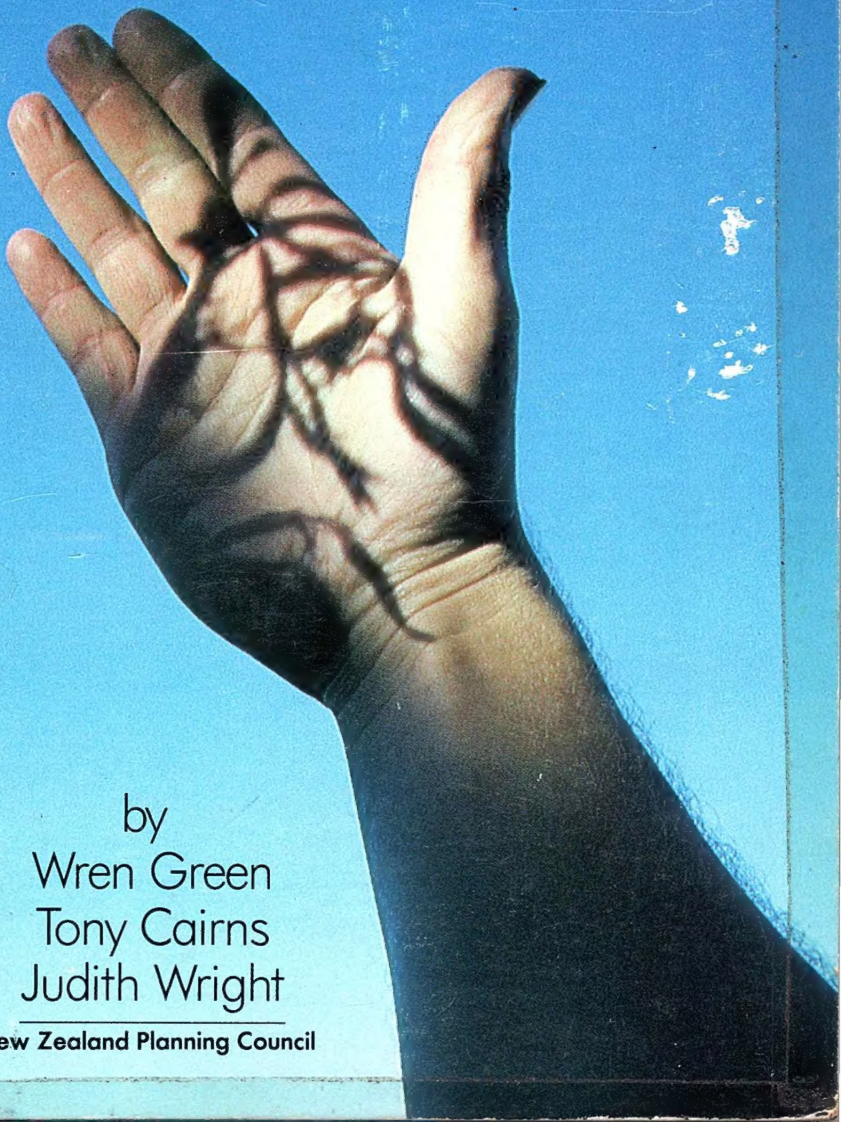
New Zealand AFTER NUCLEAR WAR



by
Wren Green
Tony Cairns
Judith Wright

New Zealand Planning Council

NEW ZEALAND AFTER NUCLEAR WAR

It is essential that not only governments but also the peoples of the world recognise and understand the dangers in the present situation.... Removing the threat of a world war – a nuclear war – is the most acute and urgent task of the present day.

United Nations General Assembly
First Special Session on Disarmament

Our representatives depend ultimately on the decisions made in the village square ... to the village square we must carry the facts.

Albert Einstein

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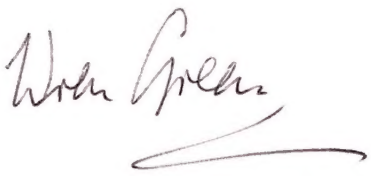

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CONTENTS

FOREWORD 8

INTRODUCTION 9

1 RESEARCH METHODOLOGY AND ASSUMPTIONS 11
Previous research
Reasons for this study
Methodology
Study assumptions
Basis of the assumptions

2 SOME IMPORTANT QUESTIONS ABOUT NUCLEAR WAR 21
How likely is nuclear war?
Would New Zealand be a target?
What is nuclear winter?
How many people would die?
How would the Southern Hemisphere be affected?

3 RADIOACTIVE FALLOUT 33
What is radioactive fallout?
Nuclear war impacts
Post-war responses
Policy issues

4 THE DEVASTATING EFFECTS OF AN ELECTROMAGNETIC PULSE 45
What is an EMP?
What are the effects of an EMP?
Can equipment be protected from EMP?

5 HOW PEOPLE MIGHT REACT 52
Historical comparisons
Likely reactions
Policy issues

6 VULNERABILITY OF COMMUNICATIONS 61
Nuclear war impacts
Post-war responses
Policy issues

7 IMPACTS ON HEALTH 68
Nuclear war impacts
Post-war responses
Policy issues

8 MEETING NEW ZEALAND'S FOOD NEEDS 79
The impact of nuclear war on food production
Impacts on food processing
Problems of distribution and access to food
Rural consequences of an EMP
Post-war responses
Impacts and options for the dairy industry
Policy issues

9 IMPACTS ON ENERGY SYSTEMS 92
Nuclear war impacts
Post-war adjustments
Nuclear war impacts with an EMP
The effect of an EMP on energy supply
Policy issues

10 DISRUPTIONS TO TRANSPORT SYSTEMS 105
Nuclear war impacts
Disruptions caused by an EMP
Post-war responses
Policy issues

11 INITIAL IMPACTS ON THE FINANCIAL SECTOR 112
Immediate impacts
Consequences of uncertainty
Post-war adjustments
Policy issues

12 ECONOMIC DISRUPTIONS FOLLOWING LOSS OF TRADE 117
Nuclear war impacts
Southern Hemisphere trade
Policy issues

13 CHANGES TO THE NATURAL ENVIRONMENT 122
Changes to marine and coastal regions
Changes to lakes and rivers
Changes to forests

14 REFUGEES 126
Post-nuclear war refugees
Pre-war refugees
People in transit
Ethical dilemmas
Policy issues

15 LINKS WITH SOUTH PACIFIC ISLANDS 133
Trade and foreign aid
Food production

Migration
Communications
Policy considerations for the South Pacific region
Policy considerations for New Zealand

16 OPTIONS FOR GOVERNMENT: RESPONSES TO CRISIS 138
Contingency planning
Responses during the crisis period
Government roles after the crisis period
Policy issues

17 CONCLUSIONS 146
Summary
What to do

ACKNOWLEDGEMENTS 153

REFERENCES 157

APPENDIX 1: PUBLIC OPINION SURVEY 162

APPENDIX 2: LIST OF BACKGROUND PAPERS 166

LIST OF FIGURES

Fig. 1/ Australian targets and generation of electromagnetic pulse (EMP) 19

Fig. 2/ Effect of smoke from fires on atmospheric temperatures 24

Fig. 3/ Human population at risk from direct and indirect effects of nuclear war 28
A Present distribution of human population
B Survivors after direct effects of explosions (heat, blast, radiation)
C Survivors after one year given additional mortality through starvation

Fig. 4/ Approximate distribution of radioactive fallout from Northern Hemisphere explosions 36

Fig. 5/ Effects of radiation doses 41

Fig. 6/ Interdependence of energy systems 95

Fig. 7/ Natural gas pipelines and some major energy facilities in the North Island 99

Fig. 8/ End use of diesel (1985) 106

Fig. 9/ End use of petrol (1985) 107

Fig. 10/ The hemisphere projection as centred on Wellington 128

LIST OF TABLES

Table 1: Estimate of the likelihood of unintentional nuclear war 22

Table 2: Impact of losses of imported medicines 70

Table 3: Impact of losses of imported medical supplies and equipment 71

Table 4: EMP effects on energy systems 101

FOREWORD

NUCLEAR WAR IS A POSSIBILITY THAT MUST BE FACED, however horrifying the prospect might be. The Planning Council undertook this study of the impacts on New Zealand of a nuclear war because it felt the possibility should be examined rather than ignored. The outcome of the study justifies this judgement. The issues for New Zealand are very different from those most commonly perceived. Knowing what they are should encourage our efforts to prevent nuclear war and give us some basis for coping should prevention fail.

The project has been difficult and challenging. Information from many unrelated sources had to be assembled, assessed and assimilated. The task of the project team would have been impossible without the assistance of the many people in New Zealand and overseas who willingly gave their time and energy to it.

This was intended to be a preliminary study. The team has achieved much more than that. While no study of such a complex, hypothetical event can be definitive and more research and information is needed, the team has taken its work beyond the preliminaries to the point where proposals for action can be properly considered.

Readers will find this report useful for more than its designed purpose. In the course of exploring the impacts of a nuclear war, the authors have provided a valuable picture of the mechanics of New Zealand society and thrown light on the roles and interdependencies of its elements.

The report is only part of the result of the project. The background papers from which it is drawn and the Planning Council's recommendations for further study and action are also available from the Council.

Funds for the project came through the Ministry for the Environment. The Minister's forbearance in granting an extension of time to complete the study and in respecting the Planning Council's independence is appreciated.

To the authors Wren Green, Tony Cairns and Judith Wright, other members of the study team and the many contributors within and outside the Planning Council's secretariat I offer the Council's thanks.

GARY HAWKE
Chairperson

INTRODUCTION

THIS BOOK IS THE RESULT OF A STUDY of how New Zealand would be affected by a nuclear war. A team was set up under the auspices of the New Zealand Planning Council, after the government allocated $125,000 from reparations paid as a consequence of the sinking of the Rainbow Warrior in Auckland Harbour. The six month contract stated that the study should be a preliminary overview, looking at environmental, social and economic impacts on New Zealand of a major nuclear war in the Northern Hemisphere and identify important issues where further second-phase studies and actions are required. This study assumes New Zealand was *not* a direct target.

The time constraint meant that the material had to be gathered as quickly as possible. This, and the wide range of topics studied, has meant that there may be inaccuracies in the report, and there are most certainly omissions. However, it is the view of the authors that the order of any errors or omissions is not so great as to detract from the overall message, that catastrophic long-term impacts would be experienced in New Zealand, not from environmental effects, but from major social disruptions that would spread to every aspect of life in New Zealand.

It was discovered in the course of this study that public understanding of the issues reflects a Northern Hemisphere bias with fear of radioactive fallout being a major concern. Since the nuclear bombings of Hiroshima and Nagasaki, public understanding of the consequences of nuclear war has been largely limited to the direct effects of nuclear explosions. However, the indirect, long-term effects of nuclear war are now being recognised by scientists as being even more devastating, particularly for non-combatant countries.[1] For this reason considerable effort has been made to make this book useful to the general reader with the first four chapters answering some general questions about nuclear war, radiation, "nuclear winter", and the lesser known phenomenon, electromagnetic pulse (EMP).* Chapters 5-16 each give an overview of the main impacts on a

* *See Chapter 4 for detailed explanation of electromagnetic pulse and its effects*

particular sector, consider how they might be dealt with and conclude with a summary of the planning and policy issues that have been raised.

In order to study how New Zealand would be affected by a nuclear war, it was necessary to first compile information on how particular aspects of New Zealand society operate and interact. Much of the material for this report has been based on information supplied by many individuals and organisations throughout New Zealand with special expertise and knowledge. Their contributions, and detailed research have been summarised into Background Papers (see Appendix 2) which are available from the Planning Council. They provide more detail for both the scientist and the general reader.

THE AUTHORS

WREN GREEN, BSc (Hons), PhD (Environmental Science) is a member of the New Zealand Royal Society's Scientific Committee on Problems of the Environment (SCOPE), and was the New Zealand delegate to the 1985 SCOPE General Assembly in Washington DC where the findings of the international study of nuclear winter effects were presented. Dr Green is a past president of the New Zealand Association of Scientists. As a Council member of the New Zealand Ecological Society he co-ordinated the 1984 Statement on the Environmental Impacts of Nuclear War on New Zealand.

TONY CAIRNS, BA, BSc and JUDITH WRIGHT, BA, Dip. Tchg are both researchers.

RESEARCH METHODOLOGY AND ASSUMPTIONS

THIS IS A NATIONAL CASE STUDY of the effect of a nuclear war on a non-combatant, non- nuclear country far from the "war zone". It builds on both international and local investigations into the consequences of nuclear war and it is hoped that it will, in turn, prove helpful to other countries initiating national case studies on the consequences of nuclear war.

Previous New Zealand studies have concluded that local impacts were likely to be dominated by social disruptions, but they have not examined, in any detail, the massive effects of an electromagnetic pulse (EMP) and they also pre-dated the research findings now available on "nuclear winter" effects.

This study examines both environmental and social issues.

PREVIOUS RESEARCH

International research

Since the first atomic explosions in 1945, most of the research into the effects of nuclear war has been focussed on the direct effects of nuclear explosions. Weapons tests have yielded quantitative information from which the impacts of blast, fire and initial radiation have been calculated.[1,2,3] Medical studies of survivors from Hiroshima and Nagasaki have documented the

long-term effects of radiation on people.[4] Therefore, until the recent research on the indirect effects of nuclear war, scientific and public attention has focussed on the horrifying images of death by blast and radiation and the massive destruction likely to occur in combatant countries. These images now dominate people's perceptions of nuclear war even in countries that are unlikely to be direct targets of nuclear attack. This affects the way people think about nuclear war and the way they would react should it occur (Chapter 5).

The first indirect effect of nuclear war to be recognised and studied was that areas remote from a blast site could be affected by radioactive fallout. A 1954 nuclear explosion produced a zone of radioactive fallout which extended several hundred kilometres downwind from the Bikini Atoll test site. It eventually covered an area of 5000 km^2 and resulted in the study of the long-term global fallout of radioactive particles.

Depletion of the atmospheric ozone layer was the next major indirect effect of nuclear explosions to be recognised. In the 1970s, scientists discovered that nitric oxide (NO), one of the products of nuclear fireballs, could reduce the ozone layer by 15-45%.[5] Without the shielding provided by ozone in the upper atmosphere, more ultraviolet (UV) radiation would reach the earth's surface. This would increase the risk of cancers (especially of the skin) and sunburn, and adversely affect plant growth.

Another indirect consequence of nuclear war, often referred to as "nuclear winter", was recognised in 1982. It was realised that large fires started by nuclear fireballs would produce enormous amounts of sooty smoke that would absorb sunlight.[6] This reduction in the amount of sunlight reaching the earth would have a cooling effect (see Chapter 2).

The research focus on the physical and atmospheric effects was then broadened to include ecological and agricultural effects in an international collaborative effort requested by the International Council of Scientific Unions (ICSU), a non-governmental group of scientific organisations. In late 1982, the Scientific Committee on Problems of the Environment (SCOPE), began an assessment of the environmental consequences of nuclear war on behalf of ICSU. The SCOPE study[7,8] confirmed the concept of "nuclear winter" and made major advances in showing that the resultant collapse of agricultural systems could place a majority of the surviving global population at risk of starvation. Scientists realised that the indirect and long-term effects of a nuclear war could be as catastrophic as the direct effects (Chapter 2).

New Zealand research

The Commission for the Future's report *Nuclear Disaster*, published in March 1982, considered four scenarios ranging from a nuclear war in the Middle East to a global war including nuclear attacks on New Zealand. The Commission's study pre-dated information on "nuclear winter" and did not analyse in detail local social impacts or the effect of an EMP. An important result of the Commission's study, however, was the conclusion that "the impacts on New Zealand of a Northern Hemisphere nuclear war are unlikely to result from fallout or other weapon effects, and the most serious would result from the loss of trading partners." [9] G. Preddey, the principal author of the report subsequently incorporated many of these ideas in a later publication, *Nuclear Disaster. A New Way of Thinking Down Under*.[12]

In December 1984, the New Zealand Ecological Society published a survey of literature on global disruptions to climate, and interpreted them for New Zealand's circumstances.[10]

In 1985 the Royal Society of New Zealand released a report *The Threat of Nuclear War: A New Zealand Perspective* which examined general issues including weapons, the role of scientists in the nuclear arms race and disengagement strategies.[11] The medical and economic implications for New Zealand of losing trade links with Northern Hemisphere countries were considered and found to be of major importance. Other social issues were not examined.

REASONS FOR THIS STUDY

The release of the SCOPE report in September 1985 found a receptive audience amongst the New Zealand scientific community. It provided both the understanding of global impacts on which a New Zealand case study could be based and the incentive to build on the SCOPE findings at the national level.

Effects on society had been outside the brief of the SCOPE study but the report had concluded, "There is a critical need for comprehensive and concerted study of the potential societal responses to nuclear war". [8] Such studies were seen as the responsibility of individual countries to investigate.

While the scientific support in New Zealand for a study which exam-

ined both environmental and social impacts was growing throughout 1986, other related concerns were being expressed. Public interest groups, while arguing the imperative of preventing nuclear war, also saw that it would be irresponsible not to consider ways to reduce the impacts of nuclear war on New Zealand. They, and others,[12] favoured some planning to increase the likelihood of survival in New Zealand. Public support for planning was revealed in a survey for the 1986 Defence Committee of Inquiry which found that 82% of New Zealanders are "strongly of the opinion that there should be some preparation or plans being made for coping with the aftermath of a nuclear war in the Northern Hemisphere".[13] The Committee report stated the need for "a realistic assessment of the risks, consquences and measures required in the event of a nuclear conflict." These studies made it clear that there was a need for an up-to-date New Zealand case study.

METHODOLOGY

The study team was given six months to identify the conditions likely to face New Zealand following a large-scale nuclear war in the Northern Hemisphere, and investigate the impacts of those conditions on the environment, society and economy. It was therefore necessary to gather information as rapidly as possible from a wide range of sources and contributors. The approach taken was therefore primarily investigative and consultative. Because of their obvious importance, the main topics chosen were food, health, energy, communications and transport. While there are separate chapters on the effects on human behaviour and the economy they are brief because references to these two themes are made directly or indirectly throughout the chapters on all the other topics. Given more time, impacts on other sectors such as education, social welfare, manufacturing and the construction industry could also have been investigated, although this could not have been done until the impacts on the above topics were established, since to a large extent they depend on the systems providing food, energy, communications and transport and maintaining health. As a starting point, basic assumptions on the conditions likely to face New Zealand after a major nuclear war had to be established. These assumptions were developed using the available literature and in consultation with scientists, (see following section). Events leading to and during a nuclear war will not necessarily follow any specific scenario, so this study

could not possibly cover all eventualities. For practical reasons, impacts have been assessed according to a particular set of assumptions and this should be borne in mind when reading the report.

Likely responses to such post-nuclear war conditions were explored early in the study through role plays and structured discussions with several groups of people. These were very useful in identifying the potential for conflict between the responses of government and its officials and those of the general public. They underlined the vital importance of social and governmental responses.

Information and opinions were collected from organisations and individuals with specialised knowledge in particular areas, such as farmers, medical doctors, engineers, academics and city planners. Some 300 individuals were contacted, provided with the assumptions and asked a series of questions concerning the short- and long-term impacts on their area of expertise.

Their responses were refined through further consultation with other experts. Interviews were conducted with senior government officials to assess likely impacts on their departments and to find out what preparations, if any, had been made against the event of a nuclear war.

Several people were commissioned to write background papers on specified study topics. These papers draw on background literature, some of it from overseas work; on responses to the questions posed in the current study; and on discussions with the Nuclear Impacts Study team. These papers provided the base for this overview report but they are also being made available as background reading (see Appendix 2).

In order to seek opinions beyond the group of experts and officials, a public opinion survey was commissioned, based on a random sample selected to represent the New Zealand population. The aim of this survey was to find out what people think would be the likely impacts of a nuclear war on New Zealand (Appendix 1).

STUDY ASSUMPTIONS

In order to provide a starting point for analysis of the impact of a nuclear war on New Zealand, seven assumptions were made on the nature and extent of a hypothetical war. Two of the assumptions included variable outcomes to accommodate uncertainties.

1/ *A major nuclear war occurs in July in the near future.*

2/ *Bombing is confined largely to the Northern Hemisphere and New Zealand is not a target.*

3/ *Conditions in New Zealand are much as they are today with little effective planning or preparation undertaken in any pre-nuclear war crisis phase (weeks or months).*

4/ *All trade between the Northern and Southern Hemisphere ceases for the foreseeable future.*

5/ *Because of destruction of ozone in the upper atmosphere, caused by oxides of nitrogen from nuclear fireballs, ultraviolet (UV) levels increase by about 50% for a year and decline to normal over the next year.*

6a/ *Three Australian-USA communication facilities at North-West Cape (Western Australia), Pine Gap (near Alice Springs) and Nurrungar (South Australia) are all destroyed by separate nuclear strikes. Re-establishment of trade with Australia is possible, but at reduced levels.*

or

6b/ *As well as the destruction of the three communication facilities some military bases and cities are destroyed by direct targeting. These include the naval facilities at Cockburn Sound (Western Australia), Darwin's RAAF base, Canberra, and another major eastern city. In addition, a high altitude nuclear explosion 400 km above southeast Australia covers New Zealand and two-thirds of Australia with an electromagnetic pulse (EMP) (see Chapter 4). Because of the destruction in Australia and the widespread disruptions caused by the EMP, trade between the two countries collapses.*

7a/ *New Zealand experiences no significant changes in temperature.*

or

7b/ *Temperatures drop by an average of 3°C throughout the New Zealand spring months (September-November), by an average of 2°C throughout summer, and by 1°C for the following 18 months. Thus, temperatures are below average for two years in total.*

BASIS OF THE ASSUMPTIONS

The reason for assuming that war occurs in the near future was to ascertain how New Zealand would cope at its present level of preparedness and with its existing resource base and social and industrial structures. These factors change constantly and future trends may enhance or diminish New Zealand's capacity to cope. The assumption does not imply that nuclear

war is particularly likely in the near future.

While a nuclear war could occur in any season, the time of year would make a significant difference to the effects on Southern Hemisphere climate. Nuclear war during a northern summer (July) would lead to more smoke travelling south than would occur during a northern winter (Chapter 2). This smoke would block sunlight and cause surface temperatures to drop.

Since the terms of reference for the study specified a large-scale nuclear war in the Northern Hemisphere, this study assumes an escalating conflict between NATO and Warsaw Pact forces, starting with attacks against key military targets, escalating to destruction of secondary military targets, then the military industrial base and finally attacks against economic targets. Over 10,000 nuclear warheads with an explosive force of 5,000 to 6,000 megatons are assumed to be used. This general scenario for nuclear war has been used in several recent studies of the consequences of nuclear war, and was the basis for the international SCOPE study.[7,8]

The assumption that New Zealand would not be a target was developed after considering the strategic military interests of the USA and USSR as revealed through the available information on the USA's SIOP (Single Integrated Operational Plan) and expressed Soviet policy.[14,15] As stated in the Ministry of Defence Report [16] New Zealand has no military or communication facilities of major strategic importance to either superpower.

Loss of trade between hemispheres is assumed because, whilst many Northern Hemisphere countries would not be targeted during nuclear war, northern non-combatant countries would still experience the severe impacts outlined in Chapter 2. Many societies would be stressed past breaking point. Consequently, a sudden end to organised trade is likely between northern countries and more particularly with Southern Hemisphere countries. Countries would turn inwards to their own problems. Localised land-based trade might continue, but sea-based trade would effectively cease for some time.

The three Australian communication facilities (see Fig 1) are widely regarded as high priority targets because of their importance to the USA's nuclear war strategies. The latest admission of their significance as potential nuclear targets was contained in the 1987 Australian Defence Department report which stated, "... there is a need for the appropriate government bodies at various levels to undertake basic civil defence planning for the protection of the population in the areas concerned."[17]

The more extensive bombing in Australia and a high altitude explosion to generate an EMP (Assumption 6b) may be viewed as less likely, but is still plausible. Strategic analyst Desmond Ball wrote in 1983:

> "There is now a widespread acceptance within the defence community of the argument that Australia's hosting of American defence and intelligence installations is likely to involve Australia in a nuclear war in which not just the installations but perhaps also Australia's military bases and facilities, and even cities, might be targets."[18]

Assumption 6b includes New Zealand being covered by an electromagnetic pulse (EMP). While this is generally regarded as an unlikely event, it is nevertheless possible and the effects would be catastrophic, dramatically altering the picture of post-nuclear war New Zealand.

Chapter 4 discusses EMP in some detail, explaining what it is and describing the massive devastation it could cause (see Fig 1).

High altitude explosions generating EMP effects would satisfy a number of military objectives. First, the disabling of command, control, communication and intelligence centres that are integral to the military infrastructure for fighting nuclear war. Second, the crippling of industries and economic activities in countries to reduce their value as forward bases or manufacturing centres. Third, the disabling of satellites with military functions. The SCOPE report suggests that future development of space-based defensive systems ("star wars") could lead to much higher numbers of high altitude nuclear explosions in the event of nuclear war.[7]

Two high altitude explosions over Australia would be sufficient to disable the communication bases and disrupt Australia's economic activity. The EMP effects on New Zealand might therefore be the incidental outcome of an EMP-generating explosion over eastern Australia, designed to disable the Nurrungar facilities in a pre-emptive attack. Assumption 7a

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Fig 1/
Ground level explosions are shown at the three communication facilities. The high altitude explosion is centred on the south-east coast of Australia creating an electromagnetic pulse (EMP) over an area that includes New Zealand.

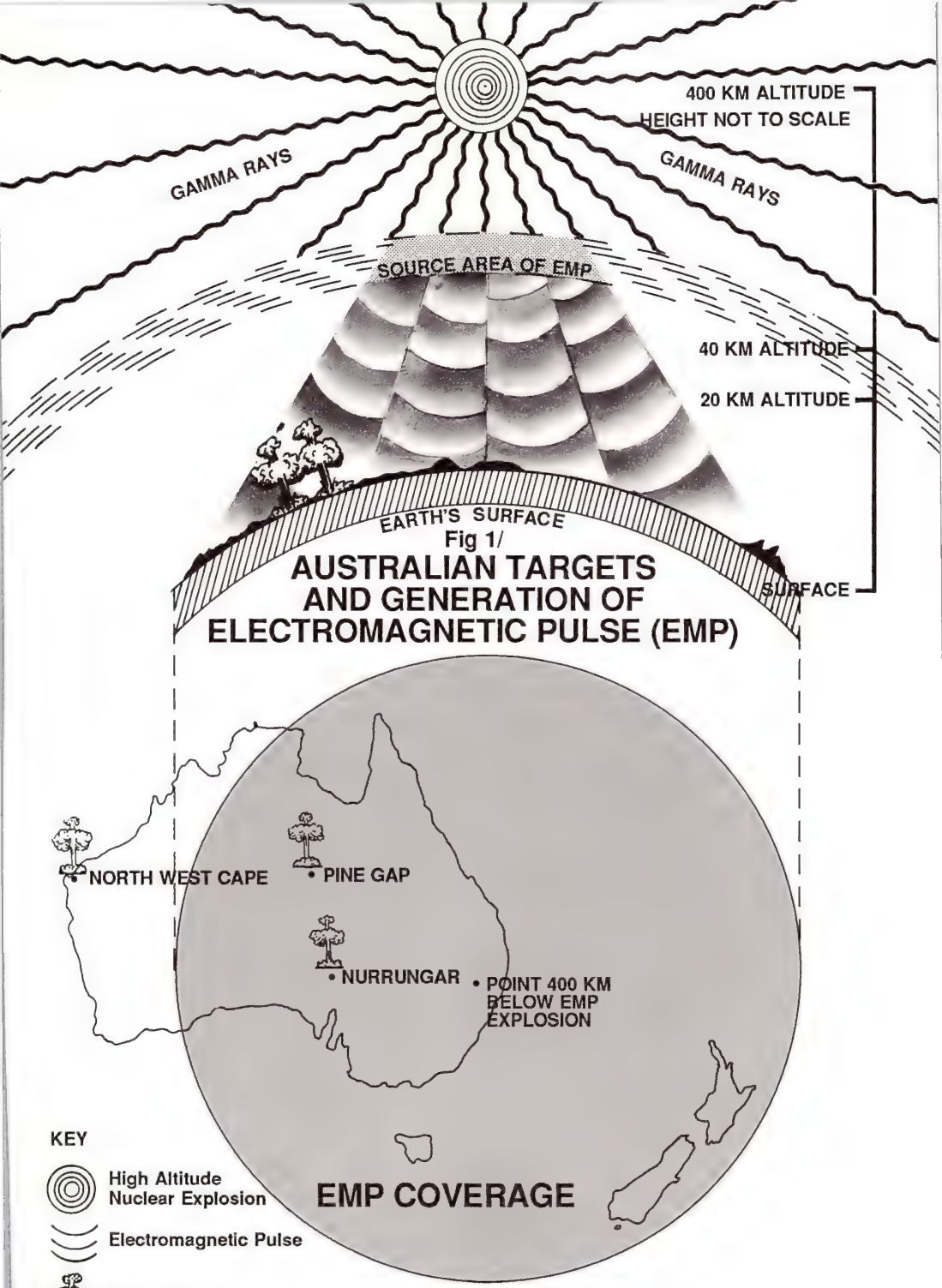


Fig 1/

AUSTRALIAN TARGETS AND GENERATION OF ELECTROMAGNETIC PULSE (EMP)

allows for a nuclear war during a Northern Hemisphere winter when the amount of smoke reaching New Zealand might be too small to affect the temperature (Chapter 2).

The temperature decreases were chosen for Assumption 7b after consultation with the SCOPE study authors. It assumes the nuclear war takes place in the Northern Hemisphere summer. The smoke from a July war would reach New Zealand in significant quantities by the end of August and would then depress spring temperatures. The smoke clouds corresponding to these temperature drops could reduce light levels by about 20% for the first year. Average temperature drops would be greatest for inland areas of Otago and central North Island.

The study assumed no change in rainfall levels. Rainfall might decrease, but the effects would probably vary between different parts of the country and cannot be usefully estimated at this time.

It is recognised that many of the assumptions are arguable since no-one can predict exactly what would happen in a nuclear war. However, the study team took all reasonable steps to ensure the assumptions were sound, searching literature and consulting with scientists and nuclear war specialists, locally and internationally.

SOME IMPORTANT QUESTIONS ABOUT NUCLEAR WAR

ALTHOUGH THE LIKELIHOOD OF NUCLEAR WAR remains small, it is still high enough to justify concern, given the severity of the impacts it would have. This chapter evaluates the likelihood of nuclear war and summarises the likely disruptions to global climate, environmental impacts, and the long-term consequences for the world's population for both Northern and Southern Hemispheres.

HOW LIKELY IS NUCLEAR WAR?

It has been said that: "Deterrence should never fail for the simple rational reason that the horrors and costs of nuclear war would be so overwhelming that no advantage could be gained from it" (USA Arms Control Agency 1975). However, dismissing the likelihood of nuclear war on these grounds is inadequate. That it is *possible* means the likelihood is greater than zero. The deterrence theory depends on it being possible since a deterrent is not effective if the enemy is certain that it will never be used.

Both superpowers have threatened to use nuclear weapons against each other during international crises several times over the past 40 years. There is no guarantee that a future crisis that escalates to a "launch-on-warning" alert will not – through human error, false alarm, system failure or bad judgement – precipitate a decision to launch nuclear missiles.

There is increasing concern over the risks of accidental nuclear war because of the enormous computerised complexity of the nuclear forces of both superpowers. In 1986, scientists from East and West at the 14th Pugwash Workshop on Accidental Nuclear War concluded that the most

probable initiators of nuclear war are irrational acts, mistakes and malfunctions. The positioning of medium-range missiles in Europe shortens the time available to make a decision to launch in the face of an apparent attack, to a few minutes (compared with 30 minutes for intercontinental missiles) and increases the possibility of human error. These developments must increase the likelihood of nuclear war.

The most detailed and thorough public analysis of the likelihood of nuclear war is the 1982 study commissioned by the United Nations Institute for Disarmament Research (UNIDIR).[1] The UNIDIR study does not include the additional risks associated with drastically reduced decision times, but it is still the most comprehensive analysis available. Its assessments of the likelihood of nuclear war occurring within a five-year period are summarised in Table 1.

TABLE 1: ESTIMATE OF THE LIKELIHOOD OF UNINTENTIONAL NUCLEAR WAR

TRIGGERING EVENT(S) *(see footnotes)*	ESTIMATED PROBABILITY FOR A MAJOR NUCLEAR WAR WITHIN 5 YEARS UNDER: *"NORMAL" CONDITIONS*	*CRISIS CONDITIONS*
1	.0001	.003
2	.0001	.001
3	.0003	.001
4	.01	.05

1/ Technical failure only (nuclear accident or false alarm).
2/ Decision to launch pre-emptive strike (global or regional).
3/ Human failure, shortcomings of men/machine systems and consequences of stress.
4/ Combination of a multitude of risks such that one failure triggers the next.

Note: Probabilities say nothing about when specific single events might occur. A probability of one unintentional nuclear war every 100 years might seem low; however, it looks more menacing given that the same probability means the war might occur this year to be followed by 99 years of "peace".

The outcome of the UN study is sobering. It estimates that during a time of international crisis unfortunate combinations of failures and errors could mean a 5% chance of nuclear war. These calculations are not exact however and assessments must remain largely intuitive.

Even though nuclear war may be unlikely, the consequences if it did occur would be so catastrophic that public concern is justified.

WOULD NEW ZEALAND BE A TARGET?

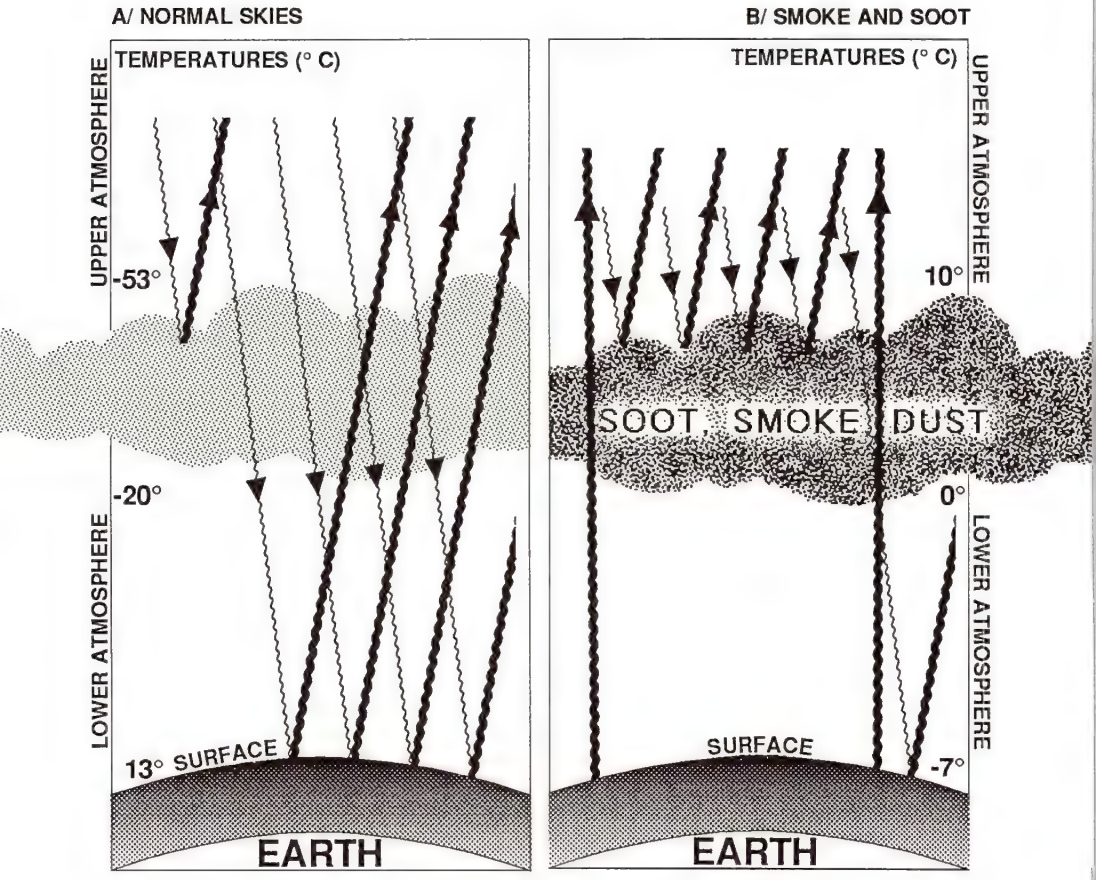
Whatever the likelihood of nuclear war, targeting strategies suggest that even though nuclear weapons arsenals now comprise over 50,000 warheads and the list of targets is growing along with the arsenals, the likelihood of New Zealand being a direct target is low. USA targets include some 40,000 military bases, economic and industrial facilities, and centres of government in the Soviet Union and Eastern Europe. Most British, French and Chinese nuclear warheads are also aimed at Warsaw Pact countries. Soviet warheads are concentrated on NATO and Chinese targets.[2]

USA military strategy distinguishes between "counterforce" targets (military) and "countervalue" targets (cities). Arkin and Fieldhouse [2] note that 7,090 counterforce targets alone have been identified in the Soviet Union and 2,830 in the United States. When thousands of industrial and economic targets are added and additional weapons assigned to allow for a percentage being destroyed, the outcome is that "... in each of the 200 largest Soviet cities, an average of 19.1 warheads with 6.33 megatons would be exploded."[2] Each one of these bombs would be, on average, 25 times more powerful than the Hiroshima bomb. The outcome would be the complete destruction of these cities, although USA policy is not to attack population centres *per se*, but the military and industrial facilities that happen to be in cities. What little is known of Soviet strategy suggests they would follow similar targeting choices.[2]

In summary, the targets of the nuclear powers are not distributed evenly around the globe but are heavily concentrated within NATO and Warsaw Pact countries. This report therefore assumes that a major nuclear war would be confined largely to the Northern Hemisphere with Southern Hemisphere targets limited to those of strategic military importance. On this basis the study assumed likely targets in Australia, but none in New Zealand (see previous chapter).

Fig 2/

EFFECT OF SMOKE FROM FIRES ON ATMOSPHERIC TEMPERATURES



A/ Sunlight passes through clouds and warms the earth's surface. Heat radiates back into space as infra-red radiation, maintaining the overall heat balance.

B/ Soot and smoke clouds absorb sunlight and warm the upper atmosphere. However, sunlight does not reach the earth's surface. Infra-red radiation continues to leave through the smoke clouds and the resulting heat imbalance leads to cooler surface temperatures.

Source of temperature values: Nuclear Winter *O. Greene, I. Percival and I. Ridge 1985 Polity Press*

Although New Zealand might well escape being bombed in a nuclear war, it would not escape extreme disruption. Later chapters will examine the social and economic disruptions that would occur. This chapter continues with a description of "nuclear winter", and an analysis of how it might affect New Zealand.

WHAT IS NUCLEAR WINTER?

> *"Nuclear war-induced disturbances to the environment would include virtually every environmental problem of concern today – habitat destruction, species extinction, air pollutants, toxic chemicals, acid rain, ozone depletion – only on a scale of totally unprecedented extent and intensity."*[3]

The term "nuclear winter" is used in this report as a convenient metaphor for the multitude of environmental effects that could follow nuclear war. It thus includes effects such as disruptions to global agricultural systems, in addition to darkened skies and freezing temperatures. The trigger for the multiple environmental effects would be the thousands of fires started by nuclear explosions.

In a major nuclear war thousands of intense firestorms would be started in cities, industrial areas, forests and wildlands. About 70% of the populations of Europe, North America and USSR live in urban or suburban areas where fossil fuels, wood and paper products, plastics, rubber and many chemicals are heavily concentrated. The near total burnout of less than one hundred of the largest industrialised urban areas would consume 25-30% of the combustible materials in the developed world.[4]

This widespread burning of cities and industrial areas would produce enormous quantities of smoke mixed with dust from the explosions. From 25% to 35% of this smoke would be soot (carbon particles) which, being black, strongly absorbs the sunlight that normally warms the earth. Some soot and smoke would be quickly removed from the atmosphere by rain ("rainout"). The remainder (average estimates suggest 170 million tonnes) would be warmed by the absorbed sunlight and would rise above the lower altitudes in which rapid rainout occurs.

Although soot particles block incoming sunlight they are transparent to the heat that is continually returning to space from the earth's atmosphere. As a result there would be a significant heat imbalance after nuclear war – less energy would be received at the earth's surface than would be lost back

to space. Consequently the earth would cool within a few days over those Northern Hemisphere countries that had been bombed. This is the phenomenon now known as "nuclear winter" – a severe loss of light and freezing temperatures (Fig 2). The smoke clouds would spread quickly over neighbouring countries covering much of the Northern Hemisphere in one to two weeks. Thickness of the clouds would be extremely variable. Under dense patches of smoke in some areas light would be reduced to 1% of normal – the equivalent of full moonlight – in the middle of the day. Over the Northern Hemisphere mid-latitudes (30-60°N), light levels could be reduced to 5-10% of normal for the first few weeks. Clearance would be slow and would depend on how long the smoke remained in the atmosphere.

Smoke and soot particles produced in a northern "summer war" (April to October) would be heated sufficiently by sunlight to rise above the lower atmosphere (where rain is generated) and into the upper atmosphere (stratosphere). Particles would remain suspended there for months or years because they would not be subjected to rain. In winter, when there is less solar heating, particles would be less likely to be lifted into the upper atmosphere and would be more likely to be rained out in the following months. Effects through the following spring and summer would depend on the amount of smoke remaining.

Under the dense smoke clouds temperatures would drop rapidly. For a war during April to October surface temperatures in continental interiors could drop to 20°C to 40°C below normal within a few days of nuclear war. Northern mid-latitudes would have autumn or winter-like conditions for weeks or more. Freezing air masses might spill over into coastal regions and into southerly, tropical regions that rarely or never experience frost. In winter, when temperatures would already be low, the initial temperature drops below normal would not be so large. Ordinary winters would become severe winters. Temperatures in the sub-tropics could still drop well below normal in any season.

Sudden temperature drops of 25-40°C below normal would have catastrophic effects on a whole range of ecosystems, from northern grasslands to tropical forests. Mortality of plants and animals would be greatest following a "summer war" when they would be totally unprepared for freezing conditions. Even long-term temperatures of 3-5°C below average would have serious impacts on many crops. The climatic disruptions could drastically affect rainfall throughout much of the Northern Hemisphere for several months to years. The warm, smoke-laden atmosphere and

cooler surface of the earth would reduce the normal temperature gradient between earth and atmosphere that produces mixing and results in rain (Fig 2). The result would be very stable weather patterns leading to little or no rain. The monsoons which are the critical source of water to Asian and African countries could be eliminated for one or two years. Rain could also be eliminated over combatant countries for many months following a nuclear war.

The natural systems most sensitive to the low temperatures are tropical and temperate forests, lakes, streams and estuaries. Very low light levels would have greatest impact on the northern oceans, through the mortality of phytoplankton – tiny plants that are the basic food source in ocean systems. Drought would most severely affect tropical forests, grasslands, lakes and stream life.

Other environmental consequences of nuclear war should be mentioned. Many missile silos are in forests and grasslands. Attacks on these high priority targets would ignite areas of grasslands and forest that would burn out of control. Vast areas of Northern Hemisphere forest and grassland could be destroyed by fire from the initial explosions. Recurring freezes, UV radiation, radioactive fallout and toxic pollutants would kill further areas of vegetation, and make the dry dead wood vulnerable to subsequent fires. Recovery of plant communities would be slow and unpredictable.

Local radioactive fallout levels in large areas between latitudes 30° to 60°N would be lethal not only to people but also to other mammals, birds, and some plant species. From 6-20% of the total land area of NATO and Warsaw Pact countries would receive levels of fallout in the first few days that would be lethal for unprotected humans. Since coniferous plants are as susceptible to radiation as humans, the extensive pine forests of Europe and the Soviet Union would be largely destroyed by radioactive fallout, fires, loss of rain, toxic chemicals and damaging levels of radiation. Many of the large and small mammals dependent on these forests and all but the hardiest birds, would be unlikely to survive.

The urban firestorms would be filled with toxic pollutants from the burning of chemicals, petroleum products and synthetic materials. The acidity of rain water, which is already killing European and North American freshwater species and forests, would be ten times worse, especially in areas near explosions. Runoff of pollutants into estuaries would seriously damage estuarine systems.

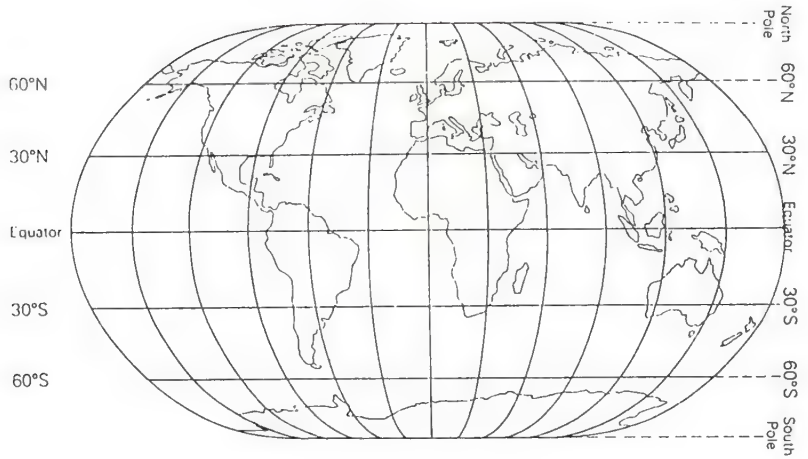
As the smoke clouds cleared, the incoming sunlight would carry higher levels of damaging ultraviolet rays (UV). These would particularly stress tropical forests, fresh water and marine systems as well as food crops. The maximum increases would occur after eight to twelve months and would take about ten years to return to normal. UV also causes physiological stress in humans, increasing their susceptibility to disease, skin cancer and cataracts.

These environmental consequences are widely referred to as "nuclear winter" although the term now includes additional effects beyond drops in light levels and temperature. The initial research and much of the initial media interest centred on the *magnitude* of the likely temperature drops in the first few weeks. Whilst subsequent research[4] has shown that the immediate fall in temperature may not be as great as was first suggested, there is agreement on two critical points. First, that there will be major

Fig 3/

HUMAN POPULATION AT RISK FROM DIRECT AND INDIRECT EFFECTS OF NUCLEAR WAR

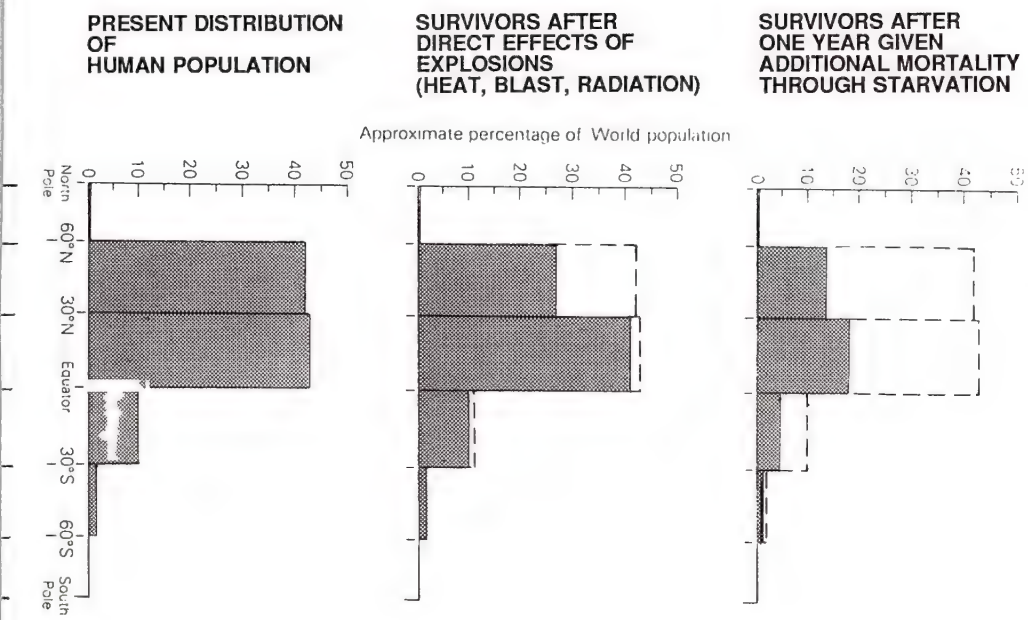
Source: *SCOPE 1985* vol 2 Chap 2, (ref 5)



disruptions to global climate following a nuclear war. Second, the impacts seem likely to continue for *longer* (perhaps years) than was first estimated. This is of greater significance than the actual degree to which the temperature would initially drop since it is the *long-term* temperature drops that would have the major impacts on agricultural production. In March 1987, new results from more complex and realistic computer models of atmospheric processes were evaluated at an international scientific conference in Thailand. The consensus was that likely climatic outcomes remain as outlined in the 1985 SCOPE report [4,5] and summarised in this chapter.

HOW MANY PEOPLE WOULD DIE?

A major nuclear war would directly kill enormous numbers of people in combatant countries. The estimates vary according to different targeting scenarios but range from 250 million to 1,000 million people, with addi-



tional millions suffering injuries.[6] The death of one billion people in probable combatant countries is shown in Fig 3. However, even greater numbers of people would be at risk of dying from starvation as the following explains.

The world's five thousand million people are heavily dependent on complex agricultural systems for their food since less than 5% of this number could be supported by natural ecosystems alone.[5] Food production is highly vulnerable to many of the environmental impacts of nuclear war as well as to the loss of modern machinery, energy, technology, and chemicals which make modern agriculture possible. Of particular significance is the effect of even minor drops in *average* temperature. On a daily and seasonal basis we are used to considerable variations in temperature, sometimes of 10-20°C. Yet over periods of several years average temperatures change very little, and it is these long-term temperature averages that are crucial. At the height of the last ice age in New Zealand, when the area under forest was severely reduced, the average temperature was about 5°C colder than at present.[7] Average Auckland temperatures were similar to those of present-day Invercargill.

Many of the world's major grain crops are sensitive to average temperature drops of much less than 5°C. For example, wheat production in Canada would probably be eliminated by a decrease of 3°C in average temperature.[5] Although the plants would grow, the reduced growing season and lack of heat would prevent the grain heads from ripening. Rice is the grain crop most sensitive to temperature drops. If temperatures fall below 15°C at critical growing periods rice grains do not form.

These, and similar analyses of many other crops, indicate that all grain production could be effectively eliminated in the Northern Hemisphere following a major nuclear war for at least one summer.[5] These conclusions would hold for the *very small* average temperature drops that are now predicted for the many months following a nuclear war. Greater temperature drops, e.g. over 5°C reduction, would far exceed the thresholds that eliminate grain crops.

These results were used in the SCOPE study to assess the potential impact on humans. From estimates of the amount of food likely to be available in a country for one year, calculations were made of the number of people that could be kept alive over that period.[5] However, several simplifying and conservative assumptions were made, such as all grains would be used to feed people not animals, and food distribution systems

would work as at present. Thus the outcome summarised in Fig 3 is not a worst case outcome.

In the vast majority of countries (excluding New Zealand, USA, Canada and Australia) there is less than one year's food supply available at any point during the year. Therefore, if international trade ceased the outcome of a nuclear war would be starvation, particularly for many of the 85% of the world's population who live north of the equator (Fig 3 C).

Nuclear war impacts would thus extend to non-combatant countries, not by blast but through starvation on an unprecedented scale. For example, Japan imports more grain then it produces annually and imports all its crude oil. Average food stores alone would be insufficient to feed the present population for a whole year. Agricultural production could be eliminated for a year or more following relatively mild climatic stresses. A 3-5°C average temperature drop would seriously reduce rice harvests, and larger decreases would eliminate Japanese rice production. Acute food shortage and large-scale mortality would be possible in such circumstances. Fatalities in India from starvation could eventually exceed the number of fatalities in the USSR and USA caused directly by nuclear explosions.

Since the likelihood of nuclear war is greater than zero and the consequences would be disastrous, there can be little doubt about the value of identifying the major consequences likely to face New Zealand.

HOW WOULD THE SOUTHERN HEMISPHERE BE AFFECTED?

If it were not a nuclear target New Zealand would not experience blast and high radiation effects of explosions. Nor would New Zealand experience rapid and substantial temperature drops given its distance from combatant countries. The perception that "nuclear winter" effects would be similar around the globe is false.

Misconceptions are inevitable when most information has tended to be from northern sources whose natural bias is to discuss global impacts from their own perspective. The catastrophic impacts felt in Switzerland or Great Britain, for example, would not be the same as those experienced in New Zealand. The effects south of the Equator would be less severe and would be different in some important respects.

The amount of smoke reaching the Southern Hemisphere would be

strongly influenced by what time of year the war occurred. A war beween April and October (i.e. northern summer) would result in the maximum amount of smoke reaching southern skies. There is normally a weak interchange of air across the Equator in the lower atmosphere. A large volume of warm smoky air could disrupt this pattern and consequently smoke would be *actively* carried into southern skies. This smoke would first arrive over New Zealand in three to four weeks, unlike the normally slow exchange via the upper atmosphere which takes a year or more.

Even so, the amount of smoke overhead after a northern summer war would be much less than that in northern skies. Compared to Northern Hemisphere light reductions of up to 95%, light levels in New Zealand could be reduced by about 20% for the first year. This would not cause freezing weather conditions although the resulting temperature drops (Chapter 1) would cut plant growth rates and have significant effects on some crops (Chapter 8). Temperature drops would be greater for southern continents. These are current estimates and further research may indicate greater amounts of smoke travelling south and thus greater temperature drops.

Changes in rainfall patterns are difficult to estimate for the Southern Hemisphere and for New Zealand. Nonetheless, general predictions from computer studies suggest a reduction in rainfall would be possible, which could produce drought conditions over Australia. Rainfall might be reduced by up to 50% over New Zealand although the effects would vary between regions.

The impact of radioactive fallout would be much less in New Zealand compared with the Northern Hemisphere. Global fallout levels in New Zealand (even if Australia were bombed) would be only 5% of average Northern Hemisphere levels. The effects of this amount of radiation are discussed in Chapter 3.

After a northern winter war (November to March) much less smoke would be sufficiently heated to rise into the upper atmosphere and disruption of the hemispheric circulation patterns is less likely. Northern Hemisphere countries would thus receive most of the smoke from a "winter" war although if sufficient smoke still remained into the spring, it could be carried south. Further research is required to evaluate these effects.

RADIOACTIVE FALLOUT

SINCE 1945 WHEN HIROSHIMA AND NAGASAKI WERE BOMBED, people have tended to think of nuclear war in terms of horrifying images of radiation illness and death. It is true that ionising radiation – or radioactive fallout – would kill millions of people in combatant countries. In a major nuclear war lethal levels of fallout could cover from 5% to 20% of the total land areas of Warsaw Pact and NATO countries within the first two days.[1] Much larger areas of the combatant countries would be covered by sub-lethal levels, causing widespread illness which might lead to death. Thus images of pervasive meaningless death and lingering pain are realistic fears for the many millions who live in the likely combatant zone of latitudes 30-60°N.

These consequences are not likely in Southern Hemisphere non-combatant countries and yet radioactive fallout is one of the main concerns New Zealanders have about nuclear war (Appendix 1). One reason for this is that most of our information about nuclear war comes from Northern Hemisphere sources. This chapter shows why radioactive fallout would not greatly affect New Zealand (assuming New Zealand is not a nuclear target) and outlines the likely impact that it would have.

WHAT IS RADIOACTIVE FALLOUT?

A fuller account of radiation terminology and effects is contained in Background Paper 9. Only the main concepts relevant to an understanding of the results are outlined here.

Nuclear explosions produce material with atoms that have unstable nuclei. These nuclei become stable by releasing bursts of energy called ionising radiation. Radiation causes damage to plants and animals when

its energy is absorbed by sensitive tissue. The term "rem" is used to measure how much radiation energy is absorbed. The process of unstable products releasing energy and becoming stable elements is called radioactive decay. Many radioactive products decay rapidly (within seconds) while others take years to decay.

The dose level of radiation that would kill 50% of fit healthy adults is 350 to 450 rem received over a two to three day period. The same dose received over a longer time, allows more chance of recovery and would kill fewer people. Thus the time over which the dose is received is an important factor. People stressed by other injuries, in shock, or without medical care could die from dose levels below 350 rem. A dose of 600 rem in a few days is almost certainly lethal. The various health effects of different levels of radiation are shown in Figure 5. Levels of 100 rem or greater would only be experienced in New Zealand if it was a nuclear target.

The radioactivity in material produced by nuclear explosions decreases rapidly with time. As a result, one hour after an explosion the radiation dose rate received from the material could be 1000 rem/hour, but after two hours the rate could have dropped to 400 rem/hour. After 10 hours the rate would drop to 63 rem/hour, and after two days to 10 rem/hour. After one month it would be about 0.4 rem/hour. Because of radioactive decay, 90% of the dose that an unprotected person would absorb would be accumulated within the first three days.

In the enormous heat and violence of nuclear fireballs (temperatures reach millions of degrees centigrade) over 300 radioactive products of some 36 different elements are produced. Four radioactive elements (iodine, cesium, strontium, plutonium) are particularly important because of their effects on humans. However their decay rates and behaviour vary enormously and they therefore pose differing threats.

Decay rates are measured as "half-lives" – the time taken for half of the original radioactivity to decay. Iodine-131 concentrates in the thyroid and has a half-life of eight days. Hence the radioactivity in a quantity of iodine-131 will be halved in eight days, and halved again in the next eight days and so on. Thus after two to three months iodine-131 is no longer emitting any significant amounts of damaging radiation. Cesium-137 has a half-life of 30 years. When taken into the body it spreads throughout most tissues, especially muscle, but is excreted in one to two years. Strontium-90 has a half-life of 28 years, resembles calcium in its biological activity, and so is absorbed into bone from which it is removed very slowly. Plutonium-239

has a half-life of 24,000 years and is very damaging if retained in the lung, liver or bone.

Radiation increases the risk of cancers of nearly all types and radiation-induced cancers are indistinguishable from "normal" cancers. Susceptibility varies enormously according to age, sex and which organ is exposed to radiation. The greater the dose of radiation, the higher the incidence of genetic diseases and cancers. Cancers from radiation associated with fallout take many years to appear. Leukemias and bone cancers appear from two to 25 years after exposure, while other cancers (including thyroid cancer) appear 10 to 40 years later. The number of extra genetic diseases is comparable to the extra cancers that would appear, but it would take several generations for all the genetic diseases to occur.

Types of fallout

Nuclear explosions lift radioactive particles various distances into the atmosphere depending on the size of the particles and the force and height of the explosion. The resulting fallout is called *early* or *local* if it returns to earth within 48 hours after the explosion. Early fallout (from radioactivity on larger particles) can cover a wide, but still restricted, area. For example, early fallout from a one megaton near-surface explosion could spread lethal radioactivity levels over about 100 x 40km (4,000 km^2) and put unprotected people at serious risk over an area of roughly 300 x 60km (18,000 km^2). Roughly 50% of all fallout from a nuclear weapon exploded at ground level (ground burst) would be early or local fallout. By contrast, an airburst (in which the fireball does not touch the ground but the explosion occurs within several kilometres of the surface) produces virtually no local fallout and all the radioactivity is delayed fallout. Only if New Zealand was a nuclear target would it receive local fallout.

Delayed fallout results from smaller radioactive particles being lifted higher into the atmosphere. Two sorts of delayed fallout can be distinguished. *Intermediate* fallout does not rise above the lower atmosphere (up to about 15 km – 1.5 times the height of Mt. Everest) and falls back to earth in rain or is pulled back by gravity within a few weeks. Intermediate fallout is deposited within the same hemisphere as its origin (Fig 4).

The other type of delayed fallout is *global* fallout which consists of very small radioactive particles carried high into the upper atmosphere. These particles are so light that they are hardly affected by gravity. Since the

Fig 4/

APPROXIMATE DISTRIBUTION OF RADIOACTIVE FALLOUT FROM NORTHERN HEMISPHERE EXPLOSIONS

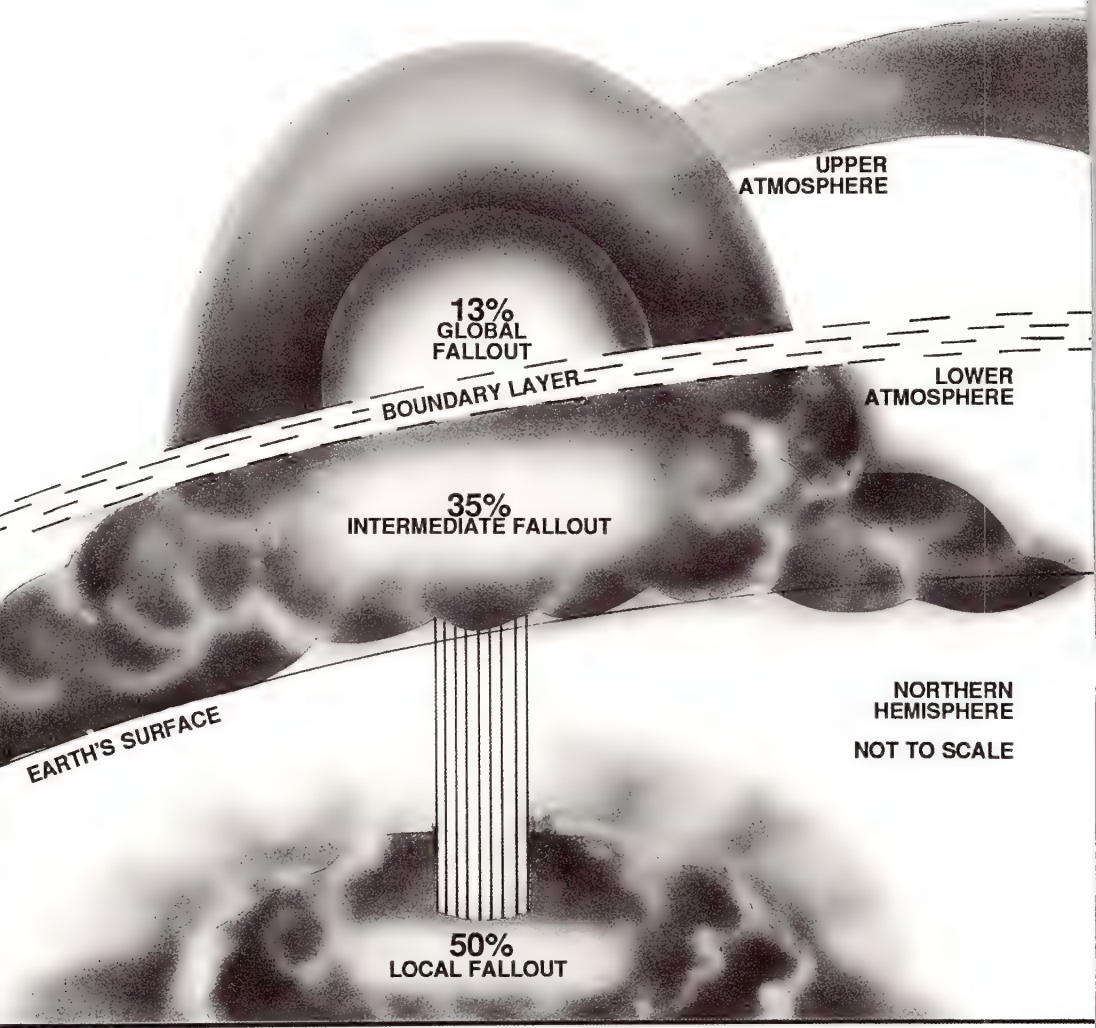
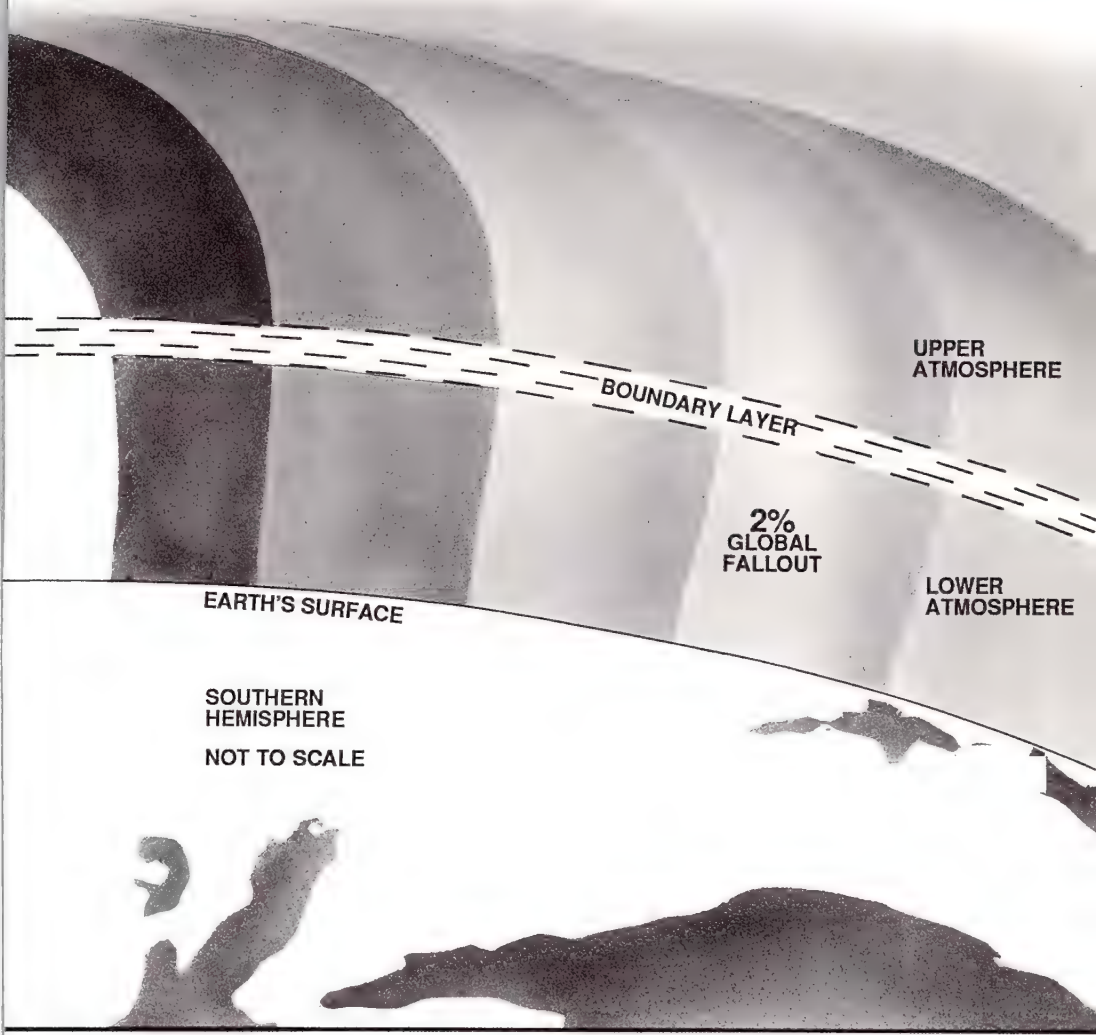


Fig 4/
Diagram only shows groundburst explosions since airbursts contribute only to intermediate and glodal fallout. Size, number and height of explosions would all influence the resulting fallout patterns. For example, total local fallout might range between 30% and 50% of all fallout. Intermediate fallout is widely dispersed over some weeks but remains in the same hemisphere as the explosion. New Zealand would receive only the small amount of Northern Hemisphere fallout that was lifted high enough into the atmosphere to be carried south.



upper atmosphere is above the rainfall zone (confined to the lower atmosphere) these small particles remain suspended for several months or years and become truly global in their distribution. Eventually they sink in cold air masses when they are subjected to rainfall and return to the earth's surface.

NUCLEAR WAR IMPACTS

New Zealand would receive global fallout from explosions in the Northern Hemisphere and delayed fallout from explosions in the Southern Hemisphere, especially if southeast Australia were targeted. The effects of these sources will be considered separately.

Fallout from Northern Hemisphere

New Zealand would not receive local and intermediate fallout because both these classes of fallout would be produced primarily in the Northern Hemisphere and would be deposited there as well. The radiation dose received in New Zealand from the Northern Hemisphere would come from global fallout that was eventually deposited over a period of decades and at least 75% of the global fallout produced in the Northern Hemisphere would return to earth within that hemisphere (Fig. 4). Although the resulting doses are difficult to estimate and depend on the nature of the war, some calculations of the likely doses that would be received in New Zealand were made in the SCOPE study.[1]

It was estimated that over a 50-year period, people in the Northern Hemisphere would accumulate an average dose of about 12 to 15 rem from delayed fallout. In some areas people could receive doses up to 10 times higher. (This would be additional to doses from local fallout.) Millions of people could develop cancers as a result. The average dose over the Southern Hemisphere would be almost 20 times lower, a total of about 0.8 rem over 50 years in New Zealand, although half of this dose would be received in the first 10 to 15 years. This value assumes that some smoke and radioactive particles would be carried rapidly into the Southern Hemisphere in a disturbed atmosphere during the first months after nuclear war. Without this rapid mixing the dose for New Zealanders would be about 0.5 rem. The radioactive element cesium-137 would be the main source. A further dose of 1 rem would be accumulated from diet (mainly

cesium-137 and strontium-90 incorporated in the food chain) over 50 years.

Thus a total dose of about 2 rem would be accumulated over 50 years by people in New Zealand from northern global fallout. This would be a *smaller* amount than the 10 rem received over the same period from natural background radiation that occurs naturally in rocks, soil and space (8 rem) and from technological sources (2 rem). In other words, people are all the time being exposed to naturally occurring and other radiation at an annual rate of accumulation of about 0.2 rem per person (Fig 5).

There is an important uncertainty in the above estimates of fallout levels. Significant additional radiation could be released if the world's non-military nuclear power plants (about 300 at present), military reactors and weapons facilities were targeted. The extent to which these nuclear facilities would be targeted and how their radioactive material would be dispersed is uncertain. Some "worst case" assumptions suggest a two to sixfold increase in total accumulated doses for humans in mid-Northern Hemisphere latitudes over a 50-year period. The possible effect on southern latitudes is very speculative. "Worst case" estimates might double or triple the total dose of 2 rem for New Zealanders over 50 years.

The increase in radiation absorbed by New Zealanders due to a Northern Hemisphere nuclear war would not cause radiation sickness, nor lead to immediate deaths, but would contribute to a long-term rise in cancer levels.

The following estimates of cancers caused solely by northern global fallout have been provided by scientists at the Institute of Nuclear Sciences, DSIR. Such estimates cannot be made with great certainty, but are sufficient to show the scale of the risk involved. They are based on a value for cancer risk within the range quoted by authoritative overseas sources. Cancer incidence was estimated assuming that each increase of 1 rem in the New Zealand population (of 3.3 million) leads to about an extra 1,000 cancers. Presuming the availability of present medical care about one-third of these cancers would be fatal.

Thus a 2 rem rise would cause 2,000 extra cancers, which would develop over a 70 year period; and cause about 700 fatalities. Fatalities would rise if medical care fell. This figure would however, be outweighed by the normal occurrence of cancer cases, which is currently 9,000-10,000 each year. Over a normal 70-year period in a population of 3.3 million, there could be 700,000 cases of cancer of which 400,000 would be fatal. The

accumulation of natural background radiation of 10 rem per person over this period would be responsible for about 10,000 of the expected 700,000 cases. Thus 2,000 extra cancers caused by fallout from a nuclear war would be undetectable because of the high normal rate of cancer.

Extra genetic abnormalities are likely to be less than the number of extra cancers (2,000) and would be spread over several generations. The extra dose to pregnant women is unlikely to exceed 0.05 rem per pregnancy. This could lead to one extra health problem in each 10,000 births, compared with 600 similar problems expected normally in this number of births.

Fallout from Southern Hemisphere

In addition to global fallout from Northern Hemisphere explosions, New Zealand would also be subjected to global fallout from Southern Hemisphere explosions. The impact would depend on the scale of the attacks. Taking the most pessimistic assumptions of the study a total amount of 15 megatons of warheads was assumed to have been exploded in the Southern Hemisphere. The extra fallout on New Zealand would provide a further dose of 0.2 to 0.6 rem over 50 years. Taking the 0.6 rem value over 50 years would add an extra 600 cancers (200 deaths) to the value for New Zealand cancers from Northern hemisphere global fallout. This would increase fallout-caused cancers by 30%.

Fallout from southeast Australia

Targeting southeastern Australia could cause intermediate fallout over New Zealand as well as global fallout. The additional radiation dose could require preventive action to reduce the health effects. The following assumes a likely worst case of 3 megatons dropped as ground-level explosions on southeast Australia. A maximum of 40% of intermediate fallout could head towards New Zealand. Some would settle by gravity over the Tasman. Assuming none is rained-out over the Tasman, the rest is available to be spread evenly by rain over the whole country. Non-iodine related doses from fallout would then total about 0.45 rem over 50 years and be responsible for about 450 extra cancers, 150 of which would be fatal. (In fact, all the fallout would not reach New Zealand as some fallout would drift on over the Pacific.)

Cancers caused by iodine-131 could be a greater problem. Iodine-131

Fig 5/

EFFECTS OF RADIATION DOSES

DOSE IN REM

is the dominant radioactive element for the first two months. It would fall on pasture, be eaten by cows, and would be a danger to people if they then consumed iodine-contaminated milk, butter and cheese. It localises in the thyroid and under these circumstances the thyroid dose could be as much as 15 rem. If no protective measures were taken the resulting thyroid disorders would include about 400 fatal cancers, 3,600 non-fatal cancers and 12,000 benign tumours. These would appear between 10 and 40 years after exposure. Since risks from iodine-131 arise mainly via dairy products, thyroid cancers would be substantially reduced if milk supplies were impounded for two to three months and pre-war stocks of dried milk powder and cheese used instead (by which time very little radioactive iodine-131 would remain). New Zealand would have ample pre-war stocks for its population though distribution could be a problem. Alternatively, distribution of potassium-iodate tablets would be an option. If taken before the fallout arrives, the iodate prevents iodine-131 from being taken into the thyroid. Present stocks are insufficient if there were a nationwide demand and, as all stocks are held in bulk store in Wellington, distribution problems would arise.

POST-WAR RESPONSES

Although the amount of fallout which might reach New Zealand might not have serious long-term impacts, fear of it is likely to provoke tremendous anxiety and a sense of helplessness amongst New Zealanders following news of nuclear war. Since radiation cannot be seen and is poorly understood by most people there would be a strong demand for frequent, accurate and clear information from qualified people. High priority should be given to providing accurate information on local fallout levels and on the implications for personal health. The National Radiation Laboratory is based in Christchurch and monitors fallout of strontium-90 and cesium-137 at three New Zealand sites. After a nuclear war they could also monitor iodine-131 and activate unused equipment at six other sites. With disruptions to transportation and telecommunications, accurate information on local fallout levels would probably require local monitoring independent of the National Radiation Laboratory. If there were an electromagnetic pulse (EMP) (see next chapter), regional independence would be essential, particularly given the likelihood that smaller, portable monitoring devices would sustain less damage from an EMP than the

equipment in the Laboratory.

If southeast Australia were targeted, iodine-131 levels would require prompt action to detect levels of contamination in milk and milk products. If those were declared unsafe, essential needs for milk would have to be met from other sources, namely safe milk powder. The demand for potassium-iodate tablets could be high. The expected source of supply would be doctors and chemists but at present neither group stocks potassium-iodate tablets.

Monitoring programmes would identify areas of low fallout where milk supplies might be acceptable with respect to strontium-90, cesium-137 and iodine-131 levels. Other methods could be used to reduce the levels of radioactivity in foods, but may not significantly reduce overall radiation exposures. These include washing fruit and leafy vegetables, avoiding certain foods (dairy produce, freshwater fish), using pre-war stored food and water purifiers.

POLICY ISSUES

Planning options should focus on three main objectives. First, to ensure that accurate, comprehensive monitoring of fallout can be maintained after nuclear war. Second, to be able to maintain effective channels of information for policy-makers and the public despite the likely disruptions. Third, to improve significantly public understanding of radiation and radiation hazards.

Total reliance on the facilities of the National Radiation Laboratory for all specialised monitoring programmes after a nuclear war would be unwise. Major vulnerabilities in communication and transport could cause unacceptable delays or make it impossible to have samples sent to Christchurch.

Consideration should be given to:

- Establishment of a system that would allow independent and effective monitoring services at a regional level. Training and extra equipment would probably be needed. People in positions with appropriate skills (in universities, health services, DSIR, and the armed services) should be identified and given responsibilities in event of emergencies.
- Evaluation of the vulnerability of radiation-monitoring equipment to an EMP and a costing of necessary countermeasures.

- Establishment of procedures for transporting samples of contaminated material (soil, air, water, milk) to the National Radiation Laboratory in emergencies.
- Establishment of supplementary specialist facilities in the North Island, for example in Wellington at DSIR's Institute of Nuclear Sciences, and/or in Auckland.
- Clearly define the hazardous levels of radioactivity for different situations and make these known along with appropriate countermeasures. This would avoid the kind of confusion amongst officials, conflicting safety standards and contradictory actions which provoked understandable public exasperation and mistrust in Europe after the Chernobyl disaster.
- Evaluation of the merits of maintaining protected stocks of food, especially dried milk and animal feed.
- Evaluation of the merits of all health boards maintaining sufficient supplies of potassium-iodate tablets for emergency needs should they be necessary.
- Additional research into regional differences between soils as they relate to the retention of contamination by pastures and crops. Identification of pathways through food chains which may lead to higher than average doses of radiation for some communities.
- A public education programme to fully inform people of the nature of ionising radiation and its potential impacts.

THE DEVASTATING EFFECTS OF AN ELECTROMAGNETIC PULSE

THE PREVIOUS CHAPTER DISCUSSED radioactive fallout in some detail because the survey commissioned for this study (Appendix 1) revealed that radiation was believed to be the most serious consequence for New Zealand after a nuclear war. However, as that chapter showed, the amount of radioactive fallout likely to reach New Zealand is many times smaller than most people envisage.

Conversely, this study reveals that people are generally unaware of a consequence which could have a far more devastating effect than either the expected amount of radiation or a "nuclear winter".

This phenomenon is the electromagnetic pulse (EMP) produced by all nuclear explosions. The higher above the ground a nuclear explosion occurs, the greater the surface area covered by an EMP. The EMP produced by ground bursts or low-level airbursts would have minor effects within several kilometres radius. Only high altitude explosions produce significant EMP effects.

While it is generally considered unlikely that such a high altitude explosion would occur over or close to New Zealand, it is considered more likely to occur over Australia.[1] There are three important joint USA-Australian military communications facilities in Australia at Pine Gap, Nurrungar and North-West Cape. Whilst intelligence experts are confident that these facilities are directly targeted by Soviet missiles, this does not also preclude the additional use of EMP as a disabling act at the initiation of a nuclear war.

Less likely but still a possibility in a nuclear war is the use of EMP-generating explosions specifically to disable Australian ports and cities in the southeast and east. A further possibility is the targeting of French

military facilities in Noumea with a high altitude explosion. Any of these scenarios could affect New Zealand with EMP. For example, if a nuclear explosion occurred 400 km above southeast Australia, New Zealand would be within range of the EMP.

WHAT IS AN EMP?

EMP effects were first noted in 1962 when a 1.4 megaton weapon was exploded by the USA 400km above Johnston Island in the Pacific Ocean. In Honolulu, 1300 km distant, 300 streetlights went out, circuit breakers blew and burglar alarms rang. The signing of the Partial Test Ban Treaty the following year ended atmospheric testing and the possibility of observing other EMP effects from high altitude nuclear explosions.

The EMP consists of a radiated pulse of electromagnetic energy produced from a region below a high altitude nuclear explosion. Gamma rays from the explosion radiate out in all directions, travelling at nearly the speed of light in empty space. The gamma rays that radiate downwards eventually collide with air molecules in the upper atmosphere (at about 20-40km height). During these collisions electrons are knocked free and move on rapidly, eventually to be slowed down by further collisions. Each of these so-called "Compton effect" electrons can generate tens of thousands of secondary electron-ion pairs. The electrons in leaving the heavier positively-charged air ions behind, cause a charge separation which in effect produces a huge current. This in turn generates a very intense electric field radiating in all directions.[2]

The whole area of interaction below the explosion becomes a huge "source region" (Fig 1) which, depending on the height of the initiating explosion can be thousands of kilometres in diameter, and from 10 to 80km above the earth. The whole area within line-of-sight of the source region would receive these very high field strengths simultaneously. The only comparable natural phenomenon is a lightning discharge, but this is both slower and more localised.

The speed and intensity of an EMP are its devastating characteristics. For example an EMP would rise to peak voltage in about 5 billionths of a second and last only one millionth of a second. Lightning discharges are about 50-100 times slower in rise time and last 100 times longer (around one thousandth of a second). Lightning almost appears as a steady current compared with the flicker of an EMP. Consequently an EMP would

overcome ordinary protective devices, such as conventional surge diverters and spark gaps, since they react too slowly.

The peak field strength from an EMP could be 50,000 to 90,000 volts/metre. By comparison the maximum field alongside a radar station is only 200 volts/metre and a normal minimum radio signal for good reception is only 2 millivolts/metre. The spectrum of the electromagnetic radiation in the EMP is also extremely wide (10 kilohertz to 100 megahertz) and includes the whole frequency band for radio transmission. Generally speaking, the high EMP field induces voltages and currents in all sorts of conducting objects. Damage to these objects can occur both because of the voltage (for example by flashover or arcing) or by heat.

The instantaneous peak-power density of an EMP is enormous – around six megawatts/m^2. However, since the pulse is so short, the energy received on the ground is small – about 0.6 joules/m^2 – much less than the 60 joules of energy a 60-watt light bulb burning for one second uses. Because of the short time involved, there is no chance to dissipate the power absorbed and sensitive components such as microchips can be burned out, despite the apparent low total level of energy. (See Background Paper 5 for more details.)

WHAT ARE THE EFFECTS OF AN EMP?

An EMP damages or destroys sensitive electrical apparatus, tripping out transmission lines and burning out electronic circuits. EMP affects electrical equipment in two major ways: by surges conducted into the apparatus from the power source or connected antennae, and by the direct effect of high electromagnetic radiation on sensitive electronic components.[3]

The energy from an EMP is collected by any conducting "antenna" exposed to the pulse. Objects that would act as antennae include power and telephone lines, metal support towers, fence wires and radio antennae.[4] The energy picked up by these collectors would travel as a surge of voltage (and thus current), to any attached equipment within milliseconds of an initial EMP burst. Likely affected equipment would include: all computers, all plugged-in radios, television sets and consumer appliances, all telephone networks, broadcasting systems and industrial control equipment.

Simultaneously, some of this equipment would also be picking up EMPs via antennae, aerials and internal wiring. Most easily damaged are very sensitive electronic items such as those using microchips (radios and

stereos, appliances such as the new washing machines and microwave ovens using microprocessors, electronic ignition in cars, computers etc). These items would not melt or explode but would immediately and permanently fail to work, and would not be easily repairable without major replacement of components.

EMP does not directly affect people unless they are in casual contact with long metallic objects such as fences, pipelines or aerials and this is a relatively low risk. There is little danger to people from the power or telephone systems because of the safety measures usually taken in such systems already, but power supplies and communications will be lost at a particularly stressful time, and they will not be restored for days, weeks or even years (see Chapters 6 and 9).

Generally, the larger the network or structure the greater the amount of intercepted energy. Thus the electricity grid, which is a very large collector, could focus large amounts of EMP energy on sensitive components both within Electricorp's and its consumers' systems. Electrical transmission systems may trip out, and permanent damage could be done to the insulation because of the peak voltages generated by EMPs of up to three million volts. High peak currents associated with these voltages of up to 10,000 amperes could also occur, but would be of very short duration and thus less potentially damaging. However they would be much greater than the design limits of most electric power systems. Household circuit breakers would respond too slowly to prevent the damaging pulse from entering household wiring, although at this level it will be much reduced in value and only the most sensitive plugged-in appliances would burn out.

It is unlikely that New Zealand's national grid could withstand such a surge in voltage and current, resulting in a total blackout. It could take between 12-24 hours to restore minimal power to major centres (i.e. sufficient power to run sewage treatment, water supply plants, and street lighting, or supply what ever other services were deemed priorities). Restoring total power would depend on the amount of damage sustained by the generators and substation equipment, and the ingenuity of the engineers in their attempts to make repairs without access to additional imported spares other than their existing stock.

It could take at least a year for the electricity system to meet even half the current demand, particularly considering that the thermal stations could not easily be repaired. This would put an increased burden on the hydro stations, which may affect their performance. Electricity would be in

limited supply during this period. Similarly, existing surge protection would be ineffective for telephone switches and cable systems. Modern telephone systems which use solid-state switching systems are also much more vulnerable than older equipment.

Of the wide variety of electrical and electronic components which would be damaged or destroyed by the surge in voltage and current caused by an EMP, smaller components are more susceptible to damage than large ones. Thus some of the most vulnerable components are microchips (integrated circuits, microprocessors etc) which have extremely low thresholds of the order of one thousandth to one millionth of the likely energy surge during an EMP. Integrated circuits are not manufactured commercially in New Zealand. Setting up an industry to do so could not be done until several other industries and technologies were developed, for instance those that could supply small parts made from stainless steel and other specialist items, machinery, chemicals and pure gases, and those that could pre-process available raw materials.

Computers and similar equipment could only be repaired if there were spare parts available, or by cannibalisation. Next in susceptibility are discrete transistors such as those in older televisions and stereos, followed by more familiar electronic components such as capacitors, resistors and inductors. Least suceptible are large components such as solenoids, relays, circuit breakers, motors and transformers. Vacuum tube (valve) equipment as in old radios, is inherently resistant to EMP effects. Battery-powered radios (not attached to the mains) would probably be undamaged since their antenna areas are small.

Although much is now known about the vulnerability of individual components and circuits, it is still very difficult to predict how an entire system would be affected and its chances of recovery. Later chapters examine how specific systems, such as communication and energy facilities would be affected by an EMP.

CAN EQUIPMENT BE PROTECTED FROM AN EMP?

Electrical equipment operating underground is generally not vulnerable to an EMP. However very little equipment is exclusively operated underground, apart from city cable networks, and even these are connected to above ground (and thus susceptible) items.

Protection (so-called "hardening") prevents damaging power surges

from reaching sensitive components of the equipment or system. While easy in principle, protection is expensive, difficult to implement and even more difficult to maintain.

There are two basic methods of protection. The first is to provide a metallic shield around sensitive equipment which will not allow the electromagnetic fields to penetrate. Protective devices to divert surges are also required on all wires or pipes leading through the shield. Such shields can be used to protect critical communications or computer installations. New techniques providing improved insulation within silicon chip wafers themselves are being developed and could be used in conjunction with other methods on new equipment. The second method is to "tailor make" the equipment at the design stage so that special parts can resist the EMP, or the effect is circumvented by turning the equipment off automatically when an EMP is sensed. Often the most cost effective protection is a combination of both these methods.

Shielding is impractical for exposed networks such as New Zealand's electric power grid. It would be possible to use high-speed gapless surge arrestors to divert over-voltages on transmission lines away from terminal equipment at substations, but at considerable cost. Disconnecting the system once an EMP is detected is impractical for technical reasons because of the speed of the pulse. Disconnecting the system before an EMP occurred could be relatively effective. One USA study looked at the time needed for system operators to isolate vulnerable equipment by remote and manual switching when a 45-minute warning of an impending attack was available, and found it would be possible to protect some 50% of the USA system. The figure in New Zealand is likely to be even higher, but it depends on the likelihood of foreknowledge of an EMP attack and whether the population would tolerate the disruption caused by such preventive measures.

Verification of the effectiveness of protection requires testing which is both complex and costly. On large networks such as the power system, it would be impossible. Otherwise, inspection and theoretical analysis must be relied upon, with its inherent uncertainty. The cost of EMP protection is high. In terms of equipment items it can add 10-30% to the cost of building a new system, or if fitted later can cost as much as the original cost of the system.

Where the cost of preventive protection is prohibitive a secondary strategy is to minimise the possibility of damage and the need for subse-

quent repair. This can involve changing operational procedures so that networks are not always fully utilised or "on line", stockpiling critical spares and keeping complete units (e.g. radio transmitters) in screened stores. Since the cost of even these measures can be considerable, the first requirement is to determine the priority of each type of infrastructure before recommending a policy of accumulating spares. Some of the most important systems vulnerable to an EMP are:

- telecommunications (telephones etc) within New Zealand and overseas
- radio and television networks and their audiences' receivers
- the national electricity grid and supply authority systems
- computer networks, particularly those recording on-line financial transactions
- control equipment operating sensitive plant such as oil refineries, sewage plants etc
- health care facilities (by combination of all the above)
- transport facilities by loss of communications and signalling.

The way in which these systems would be affected by an EMP is discussed in more detail in later chapters.

HOW PEOPLE MIGHT REACT

NUCLEAR WAR WOULD CAUSE DISRUPTIONS to practically every area of life in New Zealand. This report discusses some of them, but cannot give the definitive answer to the question "what would it be like in New Zealand after nuclear war?" How people acted and reacted would play an extremely important part in determining the characteristics of post-nuclear war society in New Zealand. It is therefore important to discuss likely human behaviour although such discussions are limited by the fact that there is no precedent. Some insights can be gained from historical accounts of people's behaviour in natural disasters such as earthquakes and floods, and technological disasters such as the Chernobyl nuclear power plant accident.

HISTORICAL COMPARISONS

Behaviour during crisis

The behaviour of people and communities in other crises gives some useful insights into their possible reactions to nuclear war. However these insights are limited by the fact that a nuclear war and a natural disaster are comparable only in some respects. Nevertheless, how people react to the first day or two of crisis is common across many cultures and is likely to be relevant to the first few days after nuclear war, and since these early responses are widely misunderstood they are worth summarising.

Contrary to popular understanding, people respond to natural disasters, such as earthquakes, floods or cyclones, with a remarkable degree of self-control and adaptive behaviour. Without waiting for outside authori-

ties to arrive, they take the initiative and make critical decisions. Anti-social behaviour, hysteria, fleeing in panic and social chaos are not common responses to natural disasters. Two concerns dominate people's behaviour: ensuring that family members are safe, and finding out what has happened. People generally give highest priority to helping their spouse, children, parents and other relatives, and to keeping family members together. Child-family relationships are particularly important, especially for children's psychological security. Families attempt to get together when disaster threatens or as soon as possible afterwards, preferably in their own homes where they decide collectively what to do next.

To make sense of the disaster, people urgently seek immediate and detailed information about its nature and scope, information about victims, about secondary threats and emergency needs. In effect, people need to reduce uncertainty about the event and its consequences in order to decide what is appropriate for them to do. They do not accept information uncritically. Rather, they will verify it with other people, discuss it with family, and then decide how to respond. The more complete and detailed the information, the more likely people will be to accept it as correct. Vague appeals for calm from nervous officials have low credibility.

Disasters rarely change people's personalities. Disturbed people and social conflicts within communities will tend to exist after disasters if they existed beforehand, in which case the problems may well be exacerbated.

Disasters also affect organisations, a fact that is often overlooked. Internal decision-making, communications, and links to other organisations can all come under pressure and be disrupted. Problems particularly arise when the potential disruptions to disaster-recovery organisations are overlooked in their planning activities.

The responses of people to the severe and widespread earthquakes in the Bay of Plenty, March 1987, were consistent with this general pattern. Anxious parents sought children at school, local people took the initiative to help neighbours and friends, and the Hahuru marae near Kawerau became a refuge for many hundreds fearful that their own homes were unsafe. While there was some looting and minor anti-social behaviour, the main response was an attempt to cope and make life as "normal" as possible. The extended family support systems of local Maori enabled them to cope more effectively than many Pakeha with the grief of losing homes and with the task of cleaning up. However, the disaster left many

people dazed and shocked, or angry that they had become victims for no apparent reason.

People tend to cope better with a disaster if they have experienced a similar event in the past, as they know what worked well or badly in the previous crisis. Organisations are generally better prepared as they have had the opportunity to sort out conflicts over roles and responsibilities that may have hampered previous recovery efforts. Information and experience increase people's ability to cope with the temporary breakdown in social and personal routines as they seek to return to normal conditions.

Long-term differences

Although the *first* reaction of people to natural disasters could have parallels to the first days after nuclear war, the long-term aftermath of nuclear war would differ significantly from the recovery sequence after natural disasters. A natural disaster is localised and lasts a relatively short time. Help is relatively quickly available from outside the disaster area, where life has been unaffected. There are authorities (police, fire service, Civil Defence, etc) whose experience is acknowledged and who are seen to be acting for the common good. Many people will know what to do based on experience or common sense for in the last resort people can fall back on their five natural senses to assess the dangers they face. Finally, the impact of the disaster is usually softened by having recourse to an insurance company or the government to help re-build or clean up damaged property.

None of these conditions would apply in the aftermath of nuclear war. With the whole country affected, no "outside" area would be there to lend assistance. As later chapters will show, the consequences would not all occur immediately and many would take months or even years to develop. "Recovery" in the usual sense of the word would be impossible and the problems of adjusting would stretch on for years. Usual authority figures would be seen not to have special expertise and their responses could promote distrust rather than co-operation. People would not be able to rely on their natural senses of sight, sound, taste, touch and smell, to detect whether they faced any risks from radioactive fallout. Lacking direct experience of nuclear war, people would have only their beliefs and incoming information to rely on.

The nuclear power station accidents at Three Mile Island (1979) and Chernobyl (1986) provide some insights into the behaviour of people faced with extraordinary threats beyond their normal experience. The strongest effect of the Three Mile Island accident (at Harrisburg, USA) was demoralisation. "Demoralisation took the form of feelings of helplessness and depression ... [and] individuals capable of appropriate actions were reduced to feelings of helplessness and dependency because the problem was beyond their realm of experience and no adequate information was available to guide them."[1]

In Europe after Chernobyl people were given confused and contradictory information about radiation levels and about what they should do. The outcome was panic in several countries, widespread fear, and serious erosion of support for authorities. People's needs for detailed accurate information were not met and the confusing terminology surrounding radiation measurements was rarely explained. Examples of the responses in three countries are instructive.[2]

The conflicting information caused general panic in Germany. Hotlines were inundated with calls; geiger counters and stocks of iodine tablets were sold out within a week. People ignored the warnings not to take the tablets and cases of iodine poisoning were reported within a few days. In France, people were outraged by the lack of information from government. A poll two weeks after the accident showed that 63% believed there had been a government "cover up". The confusion caused by the Italian government's contradictory and erroneous statements led to panic amongst the population. Supermarkets and chemists were "raided" for tinned and frozen foods, mineral water, powdered milk, baby food and iodine.

People respond to technological disasters (e.g. chemical spills, power plant accidents) about which they have little or no prior experience, in a more unpredictable and fearful way than they do to natural disasters. Undetectable threats, such as radiation, heighten these fears and cause even more panic. Three Mile Island also demonstrated the ease with which a general lack of trust in public officials can be generated by inept – or what is perceived to be inept – leadership. Since it seemed that no-one knew how serious the accident was, there was a strong desire to flee. Three Mile Island "should be a sobering reminder of the vulnerability of leaders, institutions and the social and economic organisations of contemporary industrial society."[1]

LIKELY REACTIONS

The following assessment of behavioural responses to nuclear war was based on the views and analyses of a range of people who took part in seminars, interviews, or responded to mailed requests for comments on the assumptions. They include government officials, community workers, local government representatives and officials, trade union officials, employers' representatives, doctors, lawyers, economists, sociologists, farmers, psychologists, historians, political scientists, philosophers, planners, clergy and women's group representatives. Together they provide a fair cross-section of views as to how people might behave.

Pre-war tensions

The period of international tension before nuclear war could be as short as days or weeks, or it could be many months if it were preceded by conventional war. In the latter case, people would have longer to adapt to the circumstances and government would be more likely to have taken a number of preparatory actions. During the Cuban missile crisis of 1962 New Zealanders listened and waited, sideline spectators unable to influence the outcome and unwilling to act as if nuclear war were likely. People would probably behave that way during future crises. Stresses would increase as the situation deteriorated, uncertainty would increase over what to do, many would deny that nuclear war was a possibility, and government would be reluctant to take actions that might be precipitate, alarm the public, or turn out to be unnecessary. Individuals might take precautions, such as stockpiling food or moving to places they thought would be safer, but most people would be hoping that the situation would return to normal. Measures to stockpile strategic resources might be initiated by government and industry.

Post-war reactions

In the first few weeks after nuclear war New Zealanders would experience a number of severe psychological pressures, especially those associated with loss and fear. The destruction of so much of humanity, the deaths of hundreds of millions of people in combatant countries and the abrupt loss of ties with people in other countries would overwhelm many

with traumatic feelings of loss and dislocation. The survival of relatives and friends in the Northern Hemisphere would be unknown, perhaps forever. There would be immense grief and shock. People might have strong forebodings of death even though they were alive and outwardly their local environment appeared "normal". For some people the dislocations and losses would represent "the end of everything", and they would sink into apathy. Just as people grieve over the death of relatives, so too would there be a process of grieving over these losses.

In the immediate aftermath of war people would also be coping with fears and concerns relating to personal and family well-being. People would not be certain that New Zealand was not a nuclear target and might want to leave larger cities or other potential target areas for this reason. The need for credible information would be intense. People would want to know as much as possible about circumstances overseas and about events throughout New Zealand. Separated families and friends would almost certainly overload the telephone system (Chapter 6) as they sought information and made plans to reunite. Anxiety and panic would be more likely if families failed to make contact and people would then have to travel to reach family members. Continued separation would be particularly stressful for young children, the elderly and the ill.

There would also be many areas of potential conflict. People with official duties would be torn between meeting their work obligations and looking after their own families. A number of retailing employees and shop owners that were interviewed for this study said they would probably leave their shops and go home. Widespread absenteeism would create severe problems for remaining staff over security and for the normal sale of food and other goods. Maintaining an equitable system for the distribution of food and other essential supplies would be a crucial test of central government authority. However, maintaining retail supply of essential goods is a complex process requiring continuing supply of goods via the transport system, warehousing and staff, and depending on a functioning financial system. As will be shown in later chapters, all these would suffer considerable disruptions.

Fear of radioactive fallout and uncertainty over what actions were appropriate would affect many New Zealanders. Almost half the respondents in a survey carried out for this study (Appendix 1) believed that radiation would be the most serious problem after nuclear war (though in

fact other health threats such as disease and lack of medicine would be more lethal than radioactive fallout over New Zealand, see Chapters 3 and 7). Only widespread monitoring of radiation levels, together with clear guidelines for what protective actions people should take, would be likely to contain people's long-held fears of radiation.

If people thought that there would not be enough food they might rush to stock up, especially in cities. Concern about possible radioactive fallout could add to the sense of urgency to purchase "safe" tinned food, milk powder and other essentials. Such a rush on food supplies could easily create shortages and generate its own mood of panic if it became widespread. If shops were closed panic might turn into looting. People might also take extraordinary precautions to protect their scarce resources. Of course it cannot be known that this would be the case. Such a response would not be typical of the behaviour of most New Zealanders after natural disasters, but, as stated earlier, the circumstances would hardly be comparable. Good communications and information services throughout the crisis period would be vital in order to reduce the uncertainties and rumours which lead to panic and looting in a time of stress. Rural areas and Maori communities with access to productive land were thought by some respondents to have a better chance of remaining resilient and maintaining co-operative communities. First, because they have immediate access to food sources. Second, because land was seen as the basis of power in post-nuclear war New Zealand society. Third, because there was some collective and recent experience of disasters, and community response. (These include drought, floods and earthquakes.) Fourth, because communal values and organisation, which are important for survival, are generally stronger in these parts of New Zealand society than in others.

The re-uniting of family members would be a high priority for many, and family groups would move to places where they anticipated they would be more secure and better able to take care of themselves. Urban Maori with connections to their tribal districts might seek the wider kinship support they would receive from relatives. Some Pakeha might decide to move to rural areas to stay with friends or relatives.

Urban infrastructures are so complex and impersonal that it would be more difficult for urban dwellers to adjust to any breakdowns in systems such as rubbish and sewage disposal and the supply of water. The loss of their normal roles and jobs would provide a further incentive for urban

residents to migrate to areas where self-sufficiency seemed an achievable goal.

It is likely that many people would want to travel for reasons of high personal priority soon after nuclear war. But there may be conflicts over petrol use, because during this crisis period the government might decide that, pending a national assessment of stock levels, petrol supplies should be carefully conserved, and thus be used only for emergency services. A severe restriction on petrol sales by a government trying to cope with extreme crisis could provide the basis for serious conflict between citizens and authority. Both sides would perceive their self-interest to be in the long-term national interest. They would both be faced with other severe problems. Any action by one could provoke an escalation by the other, be it people desperate for petrol to transport them to relatives and family, or a government desperate to maintain a strategic resource and, increasingly, a semblance of power and authority.

Subsequent chapters will show that an electromagnetic pulse (EMP) would leave the country without many of the stabilising elements that promote social cohesion.

In coping with all these disruptions New Zealanders would have to make the greatest number of changes in life-style, social institutions, and economic activity of any similar period in the country's history. A psychologically battered nation would be faced with structural problems that would be difficult to resolve even in "normal" circumstances. The loss of imports would mean that scarcity would be a serious problem. Scarce supplies of petrol, diesel, medicines, drugs, spare parts, electricity and gas could all be considered too important to continue being used as they are now. Who would decide such major issues of allocation? The automatic response may be "government", but for reasons discussed in Chapter 16 this is not the only, or necessarily the best, outcome. The imposition of harsh restrictions without prior consultation and general acceptance by the public could easily trigger social unrest and defiance of regulations.

Contributors to this study expressed considerable ambivalence about the appropriate role of government after nuclear war. The imposition of censorship was seen as a particular danger, given the importance to the public of receiving credible information at all times. Reverting to a World War II model for administration was seen as inappropriate because the circumstances would be so different. The allocation of resources, the huge

economic and social problems, and the need for new decision-making processes would all demand attention. Currently New Zealand society has difficulty resolving problems which are minor by comparison, such as those associated with redundancies, re-structuring, unemployment and decline in export markets. It would take high levels of initiative, co-operation, adaptability and tolerance to facilitate a return to a relatively stable, open and democratic society after the shock of nuclear war.

POLICY ISSUES

The relationship between public and government is considered in Chapter 16, but the importance of developing consultative processes and general principles for resource allocation needs to be stressed. Recovery would also depend on the resilience and ability of communities to cope co-operatively with social stresses. Identifying these positive, resilient qualities of communities and how they can be encouraged elsewhere would be of benefit in the advent of any kind of disaster. In the course of this study, it was found that New Zealanders have a poor understanding of likely impacts on New Zealand of a nuclear war. There is especially a lack of understanding of how extensive and pervasive the longer-term effects of losses of imports and export markets would be. This poor understanding reflects a lack of information, not an unwillingness to learn. The NRB Public Opinion Poll (1986) for the Defence Review[3], and responses to this study, indicate that people are receptive to accurate information and that they believe that there is a need for planning to reduce post-war problems. Improving that public understanding should be a primary objective in any planning. If people had a more realistic understanding of the likely consequences of nuclear war, they would be better able to enter into the debate on whether and how much to plan; understand the options open to government; understand why prevention is imperative; and if nuclear war were to occur, would react less destructively than they might if they were ill-informed. The following chapters are part of that process of education.

VULNERABILITY OF COMMUNICATIONS

WHAT PEOPLE DO IN A CRISIS depends largely on what information they have received upon which they can base their decisions. The flow of information depends on various systems of communication.

Today's society has developed a highly sophisticated network of communication systems including telephones, telex, computers, broadcasting and newspapers. New electronic technology is being incorporated into these systems very rapidly which is either fully imported or dependent on imported parts. Thus a loss of trade with the Northern Hemisphere would eventually cripple existing systems of communication. The development or restoration of systems which could be maintained from domestic resources would take a long time.

NUCLEAR WAR IMPACTS

Communications during crisis

During any crisis, accurate information and the ability to pass it on to the appropriate people is of paramount importance.

People are not passive receivers of information. They interpret it, judge if it is reliable, confirm it with other people, and then decide whether or not to take any action. Experience from natural disasters, and technological disasters such as Chernobyl, shows that people want to be told the truth of the situation and be given as much detail as is necessary to enable them to make decisions about what to do. Without information it is impossible to reduce uncertainty about what has happened, to find out the consequences, and take appropriate action. When the threat is invisible or distant, as it was for Europeans after Chernobyl or as it would be for New

Zealand after a distant nuclear war, the need for effective communications and accurate information is even greater.

Consequently the pressures on New Zealand's communication systems, would be intense. The telephone system would be overloaded, and unless there were alternative systems in place such as radio links, responses of officials, emergency services and government would be seriously hampered and could lead to serious delays in communications between government, officials and the public.

As long as the country was not affected by an electromagnetic pulse (EMP), government would have access to television, radio, newspapers and the wireservice. In the crisis period of the first month there is no technical reason why these communications systems should not be able to continue normal operations and they would be very important outlets for information.

Consequences of an EMP

If New Zealand suffered the direct effects of an EMP, the results for the communication systems would be disastrous, particularly considering that many of the computers and electronic communications systems of the Broadcasting Corporation, New Zealand Telecom, and most government departments (including Defence, Justice, Police and Foreign Affairs) are not protected against an EMP.

Unless protected, computers, which have become indispensable in speedy communication systems, would be damaged. Furthermore, unless copies of software or databases were stored on optical back-up disks, vital information could be lost.

The telephone system could be completely out of action because of damage to electronic telephones and to electronic exchange equipment attached to above-ground telephone wires. At present 25% of the telephone exchanges are electronic (expected to be 100% by 1990) – all of which would be damaged by an EMP. The network of fibre optic cables which carries some of the telecommunication signals would probably survive an EMP, despite their performance being degraded for the duration of the impulse and for up to an hour later, though the electronic boxes every 30-50 km along the length of the cable would be damaged. There would not be sufficient staff or electronic spares to repair the entire system immediately. Priority users (perhaps government and emergency serv-

ices) would have to be decided on.

Most international communications are via orbiting geostationary satellites and undersea cables. Both are vulnerable to an EMP and could be targets for attack. Special purpose satellites such as those used for the direct broadcasting of local television by a non-combatant country might not be a direct target but could nevertheless be extensively damaged since they would seldom be located at a distance greater than about 1000 kms from other satellites in the geostationary orbit, which is within the range of an EMP.

International communications would therefore probably be reduced to high frequency (HF) radio signals. HF radio depends for its operation on reflections from the ionosphere that occurs above about 100 kms height. Nuclear explosions create short-lived ionospheric disturbances in their immediate vicinity but the ionosphere as a whole is extremely robust. If ground terminals are available (transmitters and receivers) then HF communications would survive.

Although microwave links and broadcasting systems are fairly robust, in that they are designed to operate with high voltages present, it is unlikely they could withstand a severe EMP. So the important media outlets for information would be crippled. Newspapers are now printed on electronically-controlled imported presses. They would be inoperative without electricity and their electronic components would probably have been damaged.

With the loss of radio, television and newspapers, people would know only what they could find out for themselves. Information about events in the rest of the country and overseas would be sketchy for at least two days for the majority of the people in New Zealand until electricity could be restored to the main centres, and communication networks could be established. Central or local government people would be unable to communicate with the public and might have very limited information themselves.

POST-WAR RESPONSES

If there were no EMP

Without an EMP, communications systems should be able to operate for some months without major problems. Newsprint is made in New Zealand. Existing stocks, including export orders, normally exceed 60,000

tonnes which would suffice for three to four years with careful use. More critical would be imported components, for example printing plates and ink supplies. If the pulp mill continued operating newsprint could be stockpiled pending the final failure of machinery such as heavy rollers, bearings, and other import-dependent items.

Existing spare parts should suffice to maintain radio services for two to five years before shortages had serious impacts. Eventually, an erratic electricity supply would increasingly affect radio and television receptions and could also affect transmission where stand-by diesel generators were absent or had inadequate fuel.

Many components in sophisticated telecommunication systems, such as integrated circuits, are imported and have no locally-produced alternatives. Long-term viability of nation-wide communications would depend on re-learning how to make mechanical telephone equipment based on 1930s technology. The older telegraphic service, now being superseded by telex and facsimile operations, would be a more robust long-term system providing it could be re-built.

If there were an EMP

Communications would not cease if there were an EMP, but at first they would be limited and erratic. The limited nature of reliable information would allow rumours and misinformation to spread rapidly leading to fear and anxiety which, at worst, could degenerate into panic and social breakdown.

Two-way radio would be the most important medium for receiving information (local and international), and transmitting it throughout the country in such a crisis period. Those systems which rely on Post Office land lines to connect users to a base (e.g. truck operators, taxi companies, council vehicles) would have limited communication between mobile radios, but not back to the base. However, the amateur radio network which operates without land lines and has access to the higher radio frequencies is less likely to be damaged by an EMP, and could be the source of a highly effective communications network. There are about 6000 such operators in New Zealand, many of whom belong to the Amateur Radio Emergency Corp (AREC), an established emergency network. Many of them have access to portable power generators, and are generally adept at repairing damaged equipment. A radio link has re-

cently been established between Wellington and Auckland (which enables two-way radio coverage of two-thirds of the North Island) and there is one planned between Wellington and Dunedin. Therefore, the amateur radio operators could form a communications network throughout the country within hours.

The army would also have the ability to establish a network. The problem to solve would be how to relay information to the public, emergency services and government.

A radio station network for the major centres could be re-established within hours, though continued operation beyond a week would depend on availability of electricity, or diesel to run stand-by generators. Restoring television transmission would take considerably longer and might not be considered such a high priority since there are so few battery-operated televisions. Battery-operated radios and television sets are less likely to sustain damage from an EMP than equipment connected to the mains electricity. Once transmission was restored they would certainly be all that could be used to receive radio or television programmes until electricity was restored, which could take many months, or even years, for a significant proportion of household users. Batteries would become extremely valuable (see Chapter 9). The microwave link network, usually reserved for television transmission, could be adapted to provide voice communications and some data flow if required, as an alternative route to Post Office circuits, though with a lesser capacity.

In the longer term, newspapers might be able to adapt to manual printing machines. There could be a return to public meetings and hand posters as a way of making public announcements. Postal and courier services could continue, though they would be limited by whatever modes of transport were available. With communications thus reduced, the pace of transactions would be considerably slower and government, business and personal communications would be conducted differently.

POLICY ISSUES

New Zealand is becoming more and more dependent on imported technologies and techniques which are replacing the slow, mechanically-based systems that can be manufactured in New Zealand. After a nuclear war these technologies, which are becoming an integral part of many economic sectors, would be unavailable. The solution is not to return to a

1930s level of technology now, merely in anticipation of disaster. Neither is stockpiling a real option as it would probably be prohibitively expensive and would only buy time (although valuable time) until alternative technologies were available.

Probably the most economical and practicable course of action would be to build a degree of resilience into the communication system by encouraging the local manufacture of essential components and the shielding and hardening of vital installations. There is information available for the inexpensive shielding of radios such as those used by amateur radio enthusiasts,[1] though the economic feasibility of protecting an entire system (i.e. all telephone exchanges or computers) is questionable. It would also be desirable to retain knowledge of production, maintenance and repair techniques of superseded communication systems, for example manual telephone exchanges or pre-electronic printing presses.

Some protection of computers and software could reduce the massive disruptions that would be caused by an EMP. Critical data bases, information systems and software could be safely stored on optical disks or on hard disks kept in containers protected against EMP. Some obsolete computer systems (capable of reading the above data sources) might be protectively mothballed as "insurance", instead of being re-sold.

If earth resources satellites were unaffected by EMP they could be one of the few remaining sources of data about the changes to the environment. Their receiving systems and image-processing equipment could be hardened against an EMP, to ensure adequate reception from the satellites.

Increased use of optical fibres for communications would reduce EMP impacts as optical fibres do not act as antennae and hence do not channel EMP energy into equipment, although the electronic equipment used in conjunction with them would be vulnerable. Research into EMP effects and the vulnerability of different systems is difficult and costly. Wider dissemination of the results of published research would assist agencies and organisations involved in communications to evaluate the feasibility of protecting equipment or the need to rely on other approaches.

Besides retaining knowledge of older, more manual technologies and operating skills as a "technological insurance policy", there is a case for examining the costs of import-substitution now of key components and systems which would be unavailable after nuclear war. At the very least, an adequate knowledge of how to adapt existing manufacturing indus-

tries to produce such items, should it ever be necessary to do so, would be worth acquiring.

Government departments, emergency services and relevant private sector organisations could develop general guidelines and operational procedures for re-establishing communication networks after national disruption.

An effective communication system would play a vital role in the first few days after a nuclear war, but communications systems are very vulnerable to an EMP, and their repair depends on the availability of spare parts many of which are imported. A wider awareness of the vulnerability of communication systems would allow reasonable discussion and support for what could be expensive contingency plans.

IMPACTS ON HEALTH

FOR MANY PEOPLE the onset of sickness and disease, or even death is their main image of New Zealand after a nuclear war. This is usually linked with fears of radiation sickness. However, this chapter will show that whilst people's health would be drastically affected by a nuclear war, it is not radiation that would be the main problem.

In New Zealand's health care system the major funding and co-ordination of services is provided by central government. The high standard of health care is based on many interacting factors - a trained workforce, hospitals, health infrastructure, vaccinations, high living standards, unpolluted water supplies, effective sewerage systems and an uninterrupted flow of medicines and medical equipment from overseas. All of these factors would be disrupted by nuclear war, some catastrophically.

The result would be a marked change in the standard of life and expectations of health for many New Zealanders. Even the most common conditions (toothache, or minor chest infection) usually forgotten after a short period of discomfort and alleviated by a pain killer, or antibiotics, could have devastating results for New Zealanders after a nuclear war.

At present a large proportion of medical effort goes towards the diagnosis and treatment of degenerative diseases of old age, for example hypertension, cancer and arthritis. With limited resources society would have to accept that many of these conditions would run their natural course, with nursing care and support. Society might have to return to the standards of health which were the norm fifty years ago.

NUCLEAR WAR IMPACTS

Loss of imports

New Zealand's dependence on imports of medicinal supplies and pharmaceuticals is virtually 100%. Thus, the most serious long-term impact would follow from the loss of medicines and equipment from Northern Hemi-

sphere imports. An estimated $491,900,000 was spent on pharmaceuticals in the 1986/87 year. Without these imports the present health system would have to undergo drastic changes within a year.

New Zealand's pharmaceutical industry, based largely in Auckland, imports all active ingredients from the Northern Hemisphere. The final products manufactured from these active ingredients have a shelf life of only about two years. Even the *one* medicine that is considered "made in New Zealand" (an anticoagulant produced from the lining of sheep guts) depends on an indigenous material being processed overseas.

The loss of pharmaceutical imports would be felt over different periods of time depending on stock levels and how rapidly they were used up. At present rates of usage most pharmaceuticals would last three to six months. Controlled drugs, e.g. morphine, would last for two months. Without antibiotics, infection (e.g. staphylococcal) could spread and lead to complications and death.

Dental services would run out of equipment and expendable materials in about six months. Strict rationing would extend the life of these items to 12-18 months and then replacements would be unavailable for an extended period.

The consequences of running out of imported medicines, medical supplies and equipment are summarised for selected items in Tables 2 and 3 on pages 70 and 71.

Impacts on water supply and waste disposal

Clean water is an important factor for good health. Water supplies rely on electricity for pumping, chemicals for water treatment and spare parts for machinery. If there were no EMP, the first problem would probably be loss of chemicals for water treatment within one to six months. Chlorine supplies would be needed from local sources. Interruption of electricity supply would create pumping problems, especially for cities which rely on underground water (e.g. Christchurch).

Waste disposal in large cities relies on various types of engineering systems, transport, and a trained workforce. If refuse collection and sewerage systems were to break down, water contamination, pollution, and outbreaks of disease would result. In the longer-term, machinery at sewage treatment plants would break down if local substitutes for imported spare parts were not available.

TABLE 2: IMPACT OF LOSSES OF IMPORTED MEDICINES

IMPORTED MEDICINES	*CONSEQUENCES OF LOSS*
Antibiotics	No treatment for bacterial infection therefore complications more likely. Isolation for contagious diseases would assume greater importance. High rate of infection after surgery, more deaths. Increase in sexually-transmitted diseases.
Vaccines	Progressive return of infectious diseases (diphtheria, tetanus, whooping cough, measles, polio, tuberculosis) and increased deaths particularly among children. No protection against exotic diseases, such as cholera and plague, arriving later with refugees.
Medicines for chronic conditions	More illness and death for people with asthma, epilepsy and diabetes. Few medicines for patients with cancer and heart diseases. Some psychiatric disorders would increase in severity and consequences.
Anaesthetics	Operations limited to simpler shorter procedures using locally produced gases and ether.
Analgesics (painkillers)	Limited alleviation of pain after surgery or for acute and terminally ill people. Considerable suffering unless morphine is manufactured locally.
Oral contraceptives	Less reliable contraceptives would have to be used and the number of unwanted pregnancies would probably increase. If medical staff unable to meet the subsequent increased demand for abortions, more deaths or complications likely as a result of "back street abortions".

TABLE 3: IMPACT OF LOSSES OF IMPORTED SUPPLIES AND EQUIPMENT

IMPORTED MEDICAL SUPPLIES AND EQUIPMENT	*CONSEQUENCES OF LOSS*
X-ray film	Restrictions on many radiological examinations even with recycling of celluloid and X-ray emulsion.
Laboratory chemicals	Laboratory testing, which is a valuable aid to diagnosis, would be reduced to limited tests made with local materials and microscopes, for example haemoglobin estimation, blood count, urine examination and culture of bacteria.
Dental supplies	Present level of dental care impossible. More toothache would be experienced and tooth extraction by rudimentary methods more likely.
"High-tech" equipment	Equipment would be inoperative without replacement components over a six-months to three-year period. Without incubators many premature babies would die.
Needles and syringes	Need to recycle the limited number of old metal and glass syringes. More chance of infection from diseases transmitted by bodily fluids, e.g. AIDS and hepatitis.
Contraceptives	Dependence on sterilisation and less reliable contraceptive methods once the supplies of barrier contraceptives (condoms, diaphragm, spermicides, cervical caps) exhausted. The same possible increase of unwanted pregnancies, demands on medical staff, and risks of "back street abortions".

Infectious diseases

While the scarcity of medicines (and disinfectants) would make it difficult to control "ordinary" health hazards, several other factors would be increasing the likelihood of outbreaks of infectious and communicable diseases.

Infectious diseases spread when people are poorly nourished and under stress, when water supplies are contaminated through ineffective waste disposal or inadequate sewage treatment, and when hygiene standards decline. Vitamin deficiencies or protein malnutrition would lower resistance to disease. Shortages of soaps and disinfectants would allow skin infection to spread and infections like hepatitis would increase in incidence especially when people are in close proximity.

If the sewerage system failed, poor sanitation and sewage treatment could lead to increased cases of viral gastroenteritis (stomach upsets). Food poisoning from the bacteria salmonella, shigella or campylobacter could also lead to typhoid or excessive vomiting and diarrhea which, if not controlled, could lead to dehydration. The frail, newborn and elderly would be most at risk.

Chronic diseases arising out of untreated streptococcal infection in childhood, for example, rheumatic fever, kidney damage and rheumatic heart disease have become uncommon but these problems would probably return in the absence of penicillin. Skin infection (staphylococcal) could likewise spread and lead to septicaemia and death.

If animals were no longer being vaccinated there would be an increase in the risk of leptospirosis and tuberculosis spreading from cattle to people. Both diseases cause chronic illness.

Other factors would increase the spread of diseases. Insects and rodents (mice and rats) are disease carriers. Their numbers would increase if domestic rubbish built up and pest control became more difficult. An influx of refugees could significantly increase the risk of epidemics. Some could bring diseases not normally present in New Zealand, for example plague or cholera, which could arrive with refugees from any of the Northern Hemisphere continents many months after the war. (Contrary to people's perceptions of plague as a medieval disease, over 12 million deaths have been attributed to plague worldwide in the 20th century alone.) The necessary vaccines are not likely to be available so quarantine of infected refugees would be of the utmost importance.

The problems caused by higher incidences of all these diseases would

be exacerbated by a lack of medicines and antibiotics; thus, conditions in New Zealand could resemble those found in pre-industrialised Europe.

Estimates of the number of deaths in New Zealand from diseases after nuclear war are necessarily uncertain since non-medical factors (nutrition, sanitation, hygiene) would be critical. It has been estimated that in the United States 20% to 25% of survivors could die from communicable diseases.[1] These people would be far weaker, more susceptible to disease, and would have little of the social infrastructure that would be functioning in New Zealand, so this figure would only apply here if there were a total collapse of society, if deadly diseases arrived unchecked with refugees, and if little effort was made to overcome the dangers of food and water contamination. The death of one person in five could thus be the extreme price of social disintegration after a nuclear war, bringing additional fear and grief to families and communities.

Effect of increase in ultraviolet (UV) light

A 50% increase in ultraviolet light, caused by destruction of the ozone layer, would cause an increase in cancers (especially of the skin) and cataracts.

Additional impacts from an EMP

An EMP would cause immediate problems for the continued operation of hospitals and increase the likelihood of infectious diseases through disruption of water and sewerage systems, especially in cities which rely on underground water. Standby generators (without solid state components) in hospitals would alleviate general electricity failure after an EMP, providing voltage regulators were unaffected and diesel supplies could be maintained. For example, even Wellington Hospital's Total Energy Centre, which is one of the few using gas, requires a tonne of diesel a day. Any long-term power failures to hospitals would kill patients reliant on respirators, incubators (about 1000 per year) and dialysis machines (about 400 per year at present). Heating, cooking, lighting and laundry service all rely on electricity. "High-tech" equipment reliant on electronics would probably be permanently inoperative. Dental services would be unavailable until power supply was restored.

Supply of pharmaceuticals already in the country could be disrupted, since the packaging and processing industry might have to revert to manual methods. Fuel shortages or transportation difficulties would slow

distribution of pharmaceuticals, especially to the South Island, from the main producers in Auckland. Effective rationing of scarce resources would depend on adequate security, communication, transport and would presuppose a shared trust in the fairness of the system.

If an EMP badly damaged the electricity grid there would be problems with sewage disposal. All urban sewerage systems depend on electric pumping equipment. Some systems have diesel pumps as a standby, but these would not cope with full sewage volumes and in any case, diesel would soon be in short supply, (see Chapter 9). Uncontrolled outflows would run into harbours and rivers. Unless power was restored quickly, people would have to resort to digging holes for outdoor toilets, but these would not necessarily be sanitary and so fly-borne diseases such as dysentery and gastro-enteritis could spread quickly.

POST-WAR RESPONSES

For several months the greatest need would be to eke out available medicines and supplies for as long as possible, to obtain more from Australia if that were feasible and make local production a very high priority. Systems for requisitioning all medicines in the country, and for rationing, would be required urgently to prevent panic buying and hoarding. These could be very difficult to establish and enforce, especially without pre-war planning and given the other traumas that medical people and administrators would be trying to cope with at the time. Determining priorities would be a major obstacle, and health workers might disagree over the guidelines. Treatment might be withheld from particular groups in cases of extreme shortages. In any case, very strict rationing would only extend existing supplies of pharmaceuticals one year, or two years at the very outside.

Alternative sources would be sought. Australia, for example, could supply some important medicines (antibiotics, morphine, codeine) if trade was possible and they were willing to share scarce resources. However, if attacked by nuclear weapons, Australia would be more likely to request medical assistance from New Zealand than to offer to sell medicines.

After a nuclear war there would be a period between the exhaustion of remaining stocks and limited local manufacture when New Zealand had few medicines. In these circumstances people would experience tremendous pain and suffering. Health care would be limited to the diagnostic and treatment methods that were used before modern drugs were developed.

Local production possibilities

Eventually, assuming that there was no EMP effect or that equipment damaged by an EMP could be restored, New Zealand would have the ability to set up small-scale local production of medicines. However, this could take some years to develop. Very few herbal remedies are as effective as modern pharmaceuticals and the cultivation of plants might not be feasible if excessive climatic changes occurred.

If any medicines were to be manufactured locally, priority would have to be given to essential medicines such as antibiotics and vaccines, as these have life-saving capacity and are the medicines most needed to deal with infectious diseases.

Without pre-war planning, it would take at least two years to establish an effective pharmaceutical industry in New Zealand. In the shorter-term, priority drugs such as morphine and penicillin could probably be produced. Co-operation between existing pharmaceutical companies, people with technical know-how (pharmacists, engineers etc), and the dairy and brewing industries which have some useful equipment for large-scale pharmaceutical manufacture would be necessary. Indigenous raw materials (hydrocarbons from oil, plant extracts and animal by-products) could be used for production of some antibiotics, vaccines, and anaesthetics (e.g. ether, chloroform and nitrous oxide). Extracts from plants could be used for producing other medicines, for example, aspirin from willow bark, and morphine and codeine from opium poppy, although it could take several seasons to produce adequate quantities of the latter.

Insulin can be produced from the pancreas of cattle, pigs, or sheep but any local production would be hampered by shortages of chemicals, and would result in a low-quality product. However, even this might save the lives of many people with severe diabetes. Without pre-planning, the time necessary to establish an adequate local supply of insulin after a nuclear war might be too long to save the lives of up to 6000 insulin-dependent New Zealanders.

Some specific problems

Pregnancy rates would rise as less reliable methods of contraception would be the only ones available. Coitus interruptus, the rhythm method, natural sea sponges, locally produced spermicides, and condoms made from lamb

caecums would have to suffice as contraceptive methods, although IUDs may be able to be made. Sterilisation, in particular vasectomy, could be safely carried out. Abortion would probably be increasingly sought as contraceptive techniques failed or became unavailable, though this could be a dangerous option if medical care, equipment and drugs were not readily available. There would also be an increase in maternal and perinatal mortality in "at risk" pregnancies.

Dental care would be reduced to the basic level of alleviating pain from toothache and gum disease. Teeth straightening, cosmetic surgery, or replacing damaged/rotten teeth would be difficult or even impossible. If their air-compressors failed, high speed drills might well be replaced by more primitive models. Amalgam for filling teeth cavities could possibly be recycled, though the quality would be reduced. Once the supply of imported painkillers was exhausted (possibly after one year) there would be a higher incidence of the population suffering from toothache. Eventually, tooth extraction by forceps could be the only solution to many teeth and gum problems.

Spectacles are made from imported lenses, and although New Zealand has the expertise to extract the required raw materials to make glass (soda ash from salt products in Grasmere, sand and lime) and the expertise to grind the glass optically, the process could not happen immediately, and the finished product would be far from the quality of spectacles today. Lenses could be recycled.

The normal function of hospitals - diagnosing and treating illness - would be severely restricted once medicines ran out and equipment broke down. New priorities would need to be set for treatment, nursing care and hospital admissions. Difficult, perhaps brutal, decisions would be forced on medical staff over health care priorities for different categories of patients, some of whom may be left to die.

The quality of care that doctors, nurses, dentists, and pharmacists could offer would be particularly affected by the breakdown in the structure of the health system, hospitals and the gradual loss of medicines, medical supplies and equipment. The emphasis of health care might well change from being curative to preventive, to facilitating the recovery of the strong and comforting those for whom there would be no cure. For people with incurable disease there is still a major role for medical advice, for example in diet for patients with chronic renal failure. This "health education" would continue to be important in a post-nuclear war society.

Hospitals could become dangerous places with increased risks from infection to both workers and patients. Local care, if available, might be preferred over hospitalisation. In fact, without intensive care facilities, access to medicines and medical equipment, many acutely ill people requiring hospitalisation would in all probability die. These include people with acute conditions of appendicitis, asthma or infection such as pneumonia.

Health standards would be much lower than today. Major elective surgery such as heart valve, hip and knee replacement, coronary artery bypass, renal transplant etc would be unavailable. There would be more cases of visible, physical deformities, harelip, and club feet.

More people might try other therapies such as herbalism, osteopathy, naturopathy, hypnotherapy and acupuncture. Traditional Maori and herbal remedies would become more attractive. There are very few skilled practitioners of these therapies and training would be slow. Moreover, such therapies would have limited application to treatment of heart, respiratory, endocrine and infectious diseases.

Older techniques of isolating patients with infectious diseases in fever hospitals and sanitoriums could be revived, thus forcing a re-organisation of hospital facilities. There could be a change in the focus from medical intervention to public health, with emphasis on maintaining water and food supplies, ensuring waste and sewage disposal and enforcing quarantine (where possible). Health education would be of primary importance in assisting people to help themselves. Health workers, dispersed more widely through communities, could give information on how to prevent the spread of infectious diseases, avoid unwanted pregnancy and maintain a healthy diet.

POLICY ISSUES

Collapse of the health system and an increase in lethal diseases would compound the misery of families and communities and impede efforts to maintain economic activity. Health is central to society's wellbeing and in New Zealand the health care system is particularly vulnerable to disruption of overseas trade. Strategies to reduce this vulnerability and to promote a rapid, effective response to the post-nuclear war conditions are essential in any pre-war planning.

The central issue is whether New Zealand should develop the capacity to be self-reliant in the production of essential medicines and how this

could be achieved. A related question is the degree of stockpiling that would be possible and feasible. Some medicines last in storage for many years. Others, such as modern pharmaceuticals, last on average only about two years as finished products. On the other hand, the active ingredients will last in storage almost indefinitely. Since New Zealand already produces pharmaceuticals from imported active ingredients, stockpiling these ingredients in sufficient quantities to last, say, five years could ensure an adequate supply of essential medicines while local manufacturing capacity was being established. The cost of stockpiling should be compared with the potential cost in suffering, death and social breakdown that might otherwise occur.

The stockpiling option would be of less importance if local, self-reliant industries were to be established as commercial ventures before nuclear war. The ability to do so exists now albeit on a small scale. The hurdles involve patent restrictions and the commercial interests of overseas pharmaceutical companies. Such options would require detailed costing and may be appropriate only for crucial medicines. (See Background Paper 10 for proposed list of essential pharmaceuticals.)

Preparation of a list of essential medical equipment, inventories of such supplies, and evaluation of the feasibility of stockpiling equipment and spare parts would be of critical importance. The potential for local manufacture and recycling (e.g. silver for x-ray plates) should be studied. Plans for handling the health issues associated with nuclear war refugees, and strategies for reducing the vulnerability of the health sector in the face of the likely social problems, should be developed.

Consideration could be given to the merits of educating health personnel now as to what might be required for health care in a post-nuclear war New Zealand; and to the merits of setting in place contingency plans for requisitioning and rationing drugs and equipment; and for quarantine regulations.

The health consequences after nuclear war would depend to a large extent upon the social structure of the post-war society. The presence of a large number of medical workers and the availability of extensive medical and technological literature would make it possible for there to be worthwhile health care, however standards of health care would sharply decline.

MEETING NEW ZEALAND'S FOOD NEEDS

PRODUCING SUFFICIENT FOOD to meet local needs would be of prime importance for any country in the aftermath of nuclear war, and New Zealand would be better placed than most countries in this respect. The mass starvation predicted for many[1] would not occur in New Zealand. However, feeding the nation after a nuclear war would depend on more than just the ability to grow food. This chapter looks at how the present ability to produce food surpluses could be eroded by "nuclear winter" effects, by loss of energy and chemical inputs (such as diesel fuel, fertilisers and animal vaccines) and discusses problems associated with processing and distribution. It considers how the agricultural sector would be affected and how it might adjust to concentrating on feeding the local population. The dairy industry is used as a case study for many of these issues.

THE IMPACT OF NUCLEAR WAR ON FOOD PRODUCTION

Loss of export markets

The loss of major export markets would have a profound effect on the agricultural sector and would remove the reason for farmers and horticulturalists to produce at pre-war levels. A significant proportion of the capacity of the food processing industries (freezing works, dairy factories, canneries) would be surplus to local demand. Existing stocks of frozen meat (New Zealand exports over 40 million sheep and lambs each year), wool, dairy and horticultural products would meet local demand for months or years so long as they could be kept from spoiling, and could be distributed.

Loss of imports

Food production depends on more than conducive growing conditions and an adequate climate. New Zealand's present high level of agricultural production is sustained by a variety of imports. Without many of them the process of growing, harvesting, preserving, packaging and transporting food from farmer to consumer would be seriously affected.

Impacts of "nuclear winter" on the growing season and crops

It can be assumed that the severe nuclear winter effects expected in Northern Hemisphere countries would not occur in New Zealand. However even an average drop of only a few degrees, which may well occur (Chapter 2), would reduce the amount of food grown in New Zealand.

Knowledge of atmospheric processes is still not sufficiently advanced to predict how long "nuclear winter" effects might persist in New Zealand. And although a war during the Northern Hemisphere winter would mean there would be less effect on New Zealand, it is not known to what extent. Further computer modelling studies, based on a better understanding of the properties of smoke and atmospheric processes, are needed to reduce these uncertainties. It is possible that temperature reductions in New Zealand after nuclear war could be greater or indeed less than those upon which this study is based.

Frosts, cool temperatures and lack of water are the main factors that slow plant development and delay the maturation of crops. If crops do not get a minimum amount of heat energy over the growing season they fail to mature. Crops vary in their heat requirements for complete development.

The maximum temperature drops that a nuclear war would be likely to cause (3°C average drop in spring, 2°C drop in summer, 1°C drop for the subsequent 18 months) could increase the frost period significantly. A 1°C drop in the average minimum temperature (overnight low temperature) could add 40 to 50 days to the period when frosts could occur in warmer North Island locations. Each 1°C drop could add 15-30 days to the frost period of cooler South Island locations. (Calculations by New Zealand Meteorological Service staff.)

These predicted increases in frost periods would be significant for agriculture, since even brief periods of chilling or freezing temperatures during the growing season can kill certain crops. The following crops are frost-sensitive and could be destroyed by unseasonal frosts: green beans,

courgettes, cucumbers, kumara, melons, potatoes, pumpkin, maize, tomatoes and wheat. Although the parent plant would survive, repeated frosts could eliminate crops of apples, asparagus, citrus and stone fruit, grapes and kiwifruit.

All these crops could fail during the first year in any region if frosts occurred in spring and summer.

There are historical precedents for small temperature changes destroying crops through frost damage. In 1816 the average summer temperatures dropped by 1-2°C in the North Eastern USA, Canada and Western Europe as a result of vast dust clouds emitted into the atmosphere by Indonesia's Mt Tambora. Frosts in May, June and August of 1816 eliminated nearly all maize production and much of the Canadian wheat crop. Famine occurred in urban France and Switzerland with the failure of frost-sensitive crops. Earlier a 1°C average temperature drop from the late 16th century to around 1700 reduced growing seasons by up to a month, and grain yields fell by up to 75% in parts of Europe as a consequence.[2]

Crops that require a lot of heat energy to mature, would be at risk from the overall loss in heat energy. With the assumed temperature drops during the first year after a nuclear war, kiwifruit and citrus fruit would mature only in the far north of New Zealand. Maize yields would be reduced and wheat would fail in Southland. Canterbury wheat crops would be delayed several weeks and would be marginal, especially if hit by spring frosts which forced a late second sowing. Since grains are grown primarily in Canterbury and further south (57% of wheat, 91% of oats, 83% of barley), supplies could be insufficient for national needs. The major problem would be loss of wheat for flour, since other grains are less significant for human consumption. Potatoes would be less affected by drops in temperature (70% of potatoes are grown in the North Island), but Southland potatoes could have small yields.

Pasture growth occurs at all temperatures above 5.5°C and is not subject to frost damage so grass would continue growing through the first year of low temperatures, although the amount produced would decrease, especially in colder climates such as Southland. A Ministry of Agriculture and Fisheries computer model was used to estimate drops in pasture production for Waikato, Canterbury and Southland if the temperature were to drop as described above. The loss in pasture production over the whole first year was 19%, 29% and 36% for these three regions respectively. In the warmer second year with an average drop of 1°C, production was reduced

by 11-17%. The model predicted heavier losses in spring associated with the 3°C drop (Waikato down 34%, Canterbury 54%, Southland 66%). If the spring temperature drop was 5°C, corresponding to a more severe nuclear winter, the declines for the three spring months would be: Waikato 58%, Canterbury 78% and Southland 90%. Pastoral farmers would have management problems if such low levels of pasture growth occurred in spring.

In summary, even relatively small drops in temperature would reduce food production in New Zealand. However, the magnitude of these reductions would be extremely unlikely to put people at risk of starvation given the huge surplus of production over levels of local consumption. Livestock would not be at direct risk since pasture growth should still be sufficient for stock to survive. Important vegetable crops would still grow in most regions, although some crops could be reduced significantly by unseasonal frosts. Loss of wheat crops could be the most serious shortage, since even at times of full production New Zealand imports about one-fifth of wheat consumed annually. Loss of grain and vegetable production would be heaviest in cooler southern regions.

Radiation concerns

Contamination of food by radiation would not be a major problem in New Zealand unless southeastern Australia was targeted. In that case, milk and milk products could be a health risk leading to a rise in thyroid cancers (see Chapter 3).

Whatever the level of targeting, there would be wide concern over the amount and effects of radioactive fallout and people would require information as to what could be safely eaten. Dairy farmers in particular would need guidance about the safety of milk and, if it was necessary, the best way of dumping milk without causing environmental and public health problems. Widespread demand for local monitoring of radioactive levels would probably exceed the capacity of the present monitoring system. Fish, particularly shellfish, would require monitoring, and the degree to which they were contaminated, if at all, would be an indication of general levels of radioactive fallout.

Other problems affecting food production

Many vegetables are grown from imported seeds, particularly carrots, broccoli, cabbages, tomatoes, courgettes and lettuce. Depending on the

season in which war occurred seed stocks could be low and this would mean that future stocks could be in jeopardy. Extra crops, specifically for seed production, might need to be grown in warmer northern New Zealand to minimise effects of lowered temperature.

Crops, pasture and animals all rely on a range of imported fertilisers and trace elements to boost New Zealand's poor quality soils. Many fertiliser requirements and trace elements come from the Northern Hemisphere and alternative sources could be difficult to find. Loss of fertilisers (phosphorus, sulphur, potassium) would have minor impacts on pasture production for two years and then loss of production would be more rapid if alternative systems had not been developed. If the ammonia-urea plant continued production (Chapter 9) all local nitrogenous fertiliser needs would be met.

Serious animal diseases would re-appear after about five years as trace elements were depleted from the soils. Half of New Zealand's pastures are deficient in selenium (currently imported from Canada and Sweden), cobalt (from Zaire and central Africa) or copper and continued shortage of these trace elements could force farmers to retire about 3.4 million ha or 16% of the total area being farmed.

Without imported antibiotics there would be increased cases of animal diseases, including those caused by internal and external parasites (flystrike, lice, keds) and scabby mouth, all of which can be transmitted to humans. Although New Zealand makes animal vaccines, local production depends on the import of essential amino acids and vitamins. Present stocks would last about six months. Without strict vaccination programmes there is a high probability of cross infection of diseases from animals to people, particularly tetanus, pulpy kidney, blackleg, tuberculosis (TB) and leptospirosis.

Refugees could bring animals infected with such serious new diseases as foot and mouth, rabies, swine fever or anthrax. Without strict quarantine, or drugs, control of diseases would be difficult.

The horticulture sector would also lose imported pesticides, herbicides and fungicides which would reduce by 20-30% (see Background Paper 4) the quantity and quality of a range of fruit and vegetables. Fuel shortages would affect horticulture and cereal cropping much more than pasture farming. Harvesting would also be difficult, since most harvesting equipment relies on imported parts and fuel.

The New Zealand fishing industry would be seriously affected by lack

of imports since almost all gear, boats and machinery are imported (including fish nets, hooks and other equipment). However, only 1% of New Zealanders' food needs are presently met by this industry.

IMPACT ON FOOD PROCESSING

If problems of growing and harvesting food could be overcome, problems in preserving, processing and packaging food for transportation would be encountered.

Food is preserved to ensure supplies outside a limited growing season and to enable food to be transported to areas where it is not grown. Besides the imported spare parts for most machinery, the loss of particular items would affect the canning industry; for example, tin plate (presently imported from Japan in twice-yearly shipments) and the rubber sealant used in the manufacture of tins. Chlorine is also essential for sterilising the cans.

Oil, coal and natural gas are the main sources of energy used in the food processing industry, with electricity supplying only 12% of direct energy needs. This diversity of energy sources makes the whole sector less vulnerable to the sudden loss of a single energy source.

PROBLEMS OF DISTRIBUTION AND ACCESS TO FOOD

Few, if any, New Zealanders are self-sufficient in food. Most go to shops to buy supplies which have been through complex storage, processing and distribution systems since leaving the farm gate. Disruptions in supply could occur immediately, particularly if banks were closed, or if there was widespread panic-buying or looting. Transportation and storage of food for urban dwellers would be a major problem unless home growing was established. For example, fresh vegetable supplies for the main urban centres mostly arrive by truck and stocks are sufficient for only 2-3 days. Wellington has the longest supply lines, but Auckland's vegetable supplies are closer with 50% grown less than 50km from central Auckland.

If there were an EMP, the loss of communications and electricity and the social disruption, would affect equally people who distribute food and those who sell it. Food transport trucks might not be operating and supermarkets might not open (although fresh and frozen food would be spoiling). Without a prompt restoration of financial systems, electricity supply and communications, the number of people without work or access

to savings would grow rapidly. Scarce food would then go to those who could pay for it or take it by force. Maintaining food supplies would be an essential priority for urban areas, but even with pre-planning the problems would be formidable.

RURAL CONSEQUENCES OF AN EMP

The instant disabling of electricity and communications by an EMP would have severe consequences for the rural sector. Equipment reliant on electricity mains would be inoperative – milking machines, electric fences, irrigation pumps, deep freezers, shearing machines, heated hen batteries, electrically-heated glass houses and domestic appliances. How long supply would be lost would vary considerably between regions. Without an immediate increase in farm labour, dairy farmers would be unable to milk large herds by hand and many cows would be dried off. Production could fall by as much as 80% without a five- to sixfold increase in farm labour.

After several weeks without electricity, assuming no backup generators, food products in large industrial cool stores (frozen meat, fruit, dairy products) would spoil. Piles of rotten meat and other foods would become a public health hazard unless they were promptly disposed of.

An EMP would leave rural people with longer-term practical difficulties as well. Electricity-driven irrigation systems needed for fruit, vegetable and wheat production would be lost. Repair and replacement of farm machinery would become more difficult. Before that point was reached, rapidly dwindling supplies of petrol and diesel would have severely hampered use of farm equipment, tractors, milk tankers, and trucks taking vegetables to city markets. A switch to alternative fuels, such an CNG, ethanol, or biogas would be a long-term solution, but such fuels would be difficult to produce given all the problems caused by an EMP.

POST-WAR RESPONSES

The nature of post-war changes would vary greatly depending on whether or not there was an EMP, although both cases would impose major reorganisation on the entire agricultural sector. Everyone involved in food production – the growers, processors and distributors – would have to adapt to producing food solely for local demand, and under adverse conditions.

Despite the local needs to be met, large cuts in production would still follow from loss of export markets, and through increased stock mortality as diseases spread. If stock numbers were reduced by 75% from pre-nuclear war levels, whether through disease or deliberate policy, the millions of sheep, beef cattle and dairy cows that would have been the basis for much of the pre-war export revenue would have largely gone.

Re-orientation of production to suit local as opposed to export needs would be a difficult process. Some foods would have value as raw materials for alternative products, for example the production of various useful chemicals from dairy waste products, but such long-term solutions would not alleviate short-term disruptions.

Even if export food markets were eventually re-established, rebuilding stock numbers would only be possible with a supply of vaccines, fertilisers, trace elements and an infrastructure that met other farming requirements such as machinery, fuels and processing industries. Although the stock would have strategic value as food reserves, they would represent drastic loss of income to producers and processors unless bought by some central agency, pending later sales.

In the meantime, farming patterns would be forced to change and land would have to be put to more diverse uses as stocking rates decreased. Some sheep farming could well revert to more wool production than meat production. Some marginal hill country might be abandoned, reverting to scrub and habitat more suited to wild pig and goats. If transport became difficult, farms distant from processing industries might be used more to maintain local self-sufficient groups than to supply national needs. There could be a greater application of organic farming methods in order to overcome the loss of fertilisers.

After the initial supplies of surplus export meat and dairy products were consumed, and the surplus flocks and herds culled, vegetables would become a more important part of diet and urban areas would need to become more self-sufficient in vegetable production. In order to compensate for the lack of imported seeds, it might be necessary to build up local seed stocks during the first growing season. Regional specialisation in food types would be replaced by local diversification of crops and pastoral farming. Foods which are easy to store and which have high food value, such as the root crops potato and kumara, would be favoured, as would fruit with good keeping qualities (apples, kiwifruit). Extra plantings could compensate for losses of vegetables.

vaccine industry to continue independently of overseas trade, thus allowing much greater control over stock numbers. The feasibility of total self-reliance in animal vaccines and other animal remedies particularly antibiotics, should be investigated and would have value in the production of human vaccines as well. Similarly, the critical imports needed in food processing industries should be identified, and the feasibility of stockpiling, or developing local substitutes, should be evaluated. The vulnerabilities of the meat industry and of food processing companies needs further study.

Developments in "nuclear winter" research should be closely monitored. A better understanding of the potential long-term impacts in the Southern Hemisphere is needed given the severe loss of crops that would follow average temperature drops of, say, 3-6°C. Joint research programmes between Australia and New Zealand into regional impacts on climatic and atmospheric processes would be of mutual benefit.

There is considerable literature on alternative farming practices, new crops and older technologies for small-scale food processing, that would be of wide benefit given the constraints that would follow a nuclear war. Assembling and then distributing such material through farming organisations would be a practical way to assist farmers and communities to cope with the difficult task of adapting to post-nuclear war conditions.

IMPACTS ON ENERGY SYSTEMS

IN A MODERN, WESTERN SOCIETY SUCH AS NEW ZEALAND the fulfilment of every human need, including food, urban water supply and sewage disposal, shelter, health care, and contact with family and friends depends on energy; whether it is gas heating or diesel to power ships, or electric power to run computers. New Zealand's early reliance on wood, muscle and wind has shifted to electricity, gas, oil and coal as sources of energy. The impact of nuclear war on energy systems is, therefore, central to how New Zealand would be affected.

New Zealand's electricity is supplied primarily by hydro-generation (75%), and by thermal stations (20%) which rely on gas and coal. All thermal stations are in the North Island, as is one-third of hydro capacity. Excess demand over supply in the more populous North Island is rectified by the transfer of power from the South Island via a direct current (DC) cable across Cook Strait. Electricity is used mostly by domestic consumers (about 40%), the aluminium smelter (about 18%) and wood, pulp and paper industries (about 30%).

Natural gas comes mainly from the large Maui field, 34 km off the coast of Taranaki (90%), with a further 8% from the older and smaller Kapuni field (on-shore). The balance is from McKee, Kaimiro, and associated on-shore fields. Thirty-three percent of gas is used to generate electricity, 25% travels via pipeline to domestic, industrial and CNG (compressed natural gas) users, and the balance goes to three petro-chemical plants that produce synthetic petrol, methanol and ammonia-urea.

At present, processing of all New Zealand's liquid fuels (which for convenience will be taken to include transport fuels) occurs at the country's single refinery at Marsden Point, Whangarei. The refinery proc-

esses imported crude oils, indigenous light oils from gas fields (condensate), and also blends and adds lead to the synthetic petrol from the Motunui Synthetic Petrol plant. Without this further processing, Motunui petrol could probably be used directly as low octane, unleaded petrol for low compression engines.

New Zealand's self-sufficiency in liquid fuels will peak in 1987-1988 at about 55% of demand. Thereafter it will decline under present policies to only 27% by 2004-2005. By assuming a nuclear war "soon" this study coincides with the most favourable circumstances for levels of indigenous liquid fuels.

Coal is mined primarily (about 66%) in the North Island, around the Waikato. Two-thirds of this production is open-cast. The main consumers of coal are steel manufacturing, electricity generation, dairy factories, hospitals, freezing works and cement works.

Figure 6 emphasises the interdependence of different energy systems. Electricity is essential to control systems everywhere, especially at the refinery and synthetic petrol plant. Transport fuel, mainly diesel, is essential to the inspection and maintenance of distribution networks such as the electricity grid or pipeline system. These are primary dependencies. Others shown in the diagram may be considered secondary – the lack of coal for electricity generation would reduce output by only a few percent, although it would disproportionately affect peak demand in the North Island.

Although several different energy forms may be used to perform the same task, the ability to change from one to the other is limited by the energy-using equipment that has been installed. Over the last decade there has been a steady move to substitute natural gas for other fuels. This has involved capital investment in domestic stoves and water heaters, industrial boilers, and CNG/LPG vehicle conversions to replace equipment designed for electricity, diesel, fuel oil, coal and petrol.

NUCLEAR WAR IMPACTS

Changes in the demand for energy

Since the Northern Hemisphere is the source of over 75% of imports and the destination for nearly 80% of exports there would be a reduction in demand for energy with the cessation of many export and import-related

activities. Major users of electricity which rely on export markets such as the aluminium smelter and pulp mills would drastically cut their production. This should make it easier to cope with supply disruptions.

Demand for coal would drop with the loss of export markets and with industrial downturns in steel, paper, freezing and dairy works. This would be partly offset if domestic electricity supply were badly disrupted and there was an increase in demand for alternative fuels such as coal. Distribution of coal would depend on the availability of transport which in turn would depend on the availability of fuel.

Demand for transport fuel would also decline as export and import-related industries declined. The major user of diesel is heavy road transport, which plays an important role in transporting exports and imports around New Zealand. About 13% of diesels and 6% of fuel oil is currently used by overseas shipping and could become available for other uses.

Major changes in the demand pattern for natural gas would occur. Gas might be considered too important to burn at only 30% efficiency in power stations. Cutting this use of gas would reduce gas demand by 25-30%. The methanol and ammonia-urea plants would lose their export markets and would probably close. Closure and mothballing of the methanol plant once storage capacity was full would give enough supply for three years' consumption in New Zealand and allow for later restarting if vehicles were converted to run on methanol.

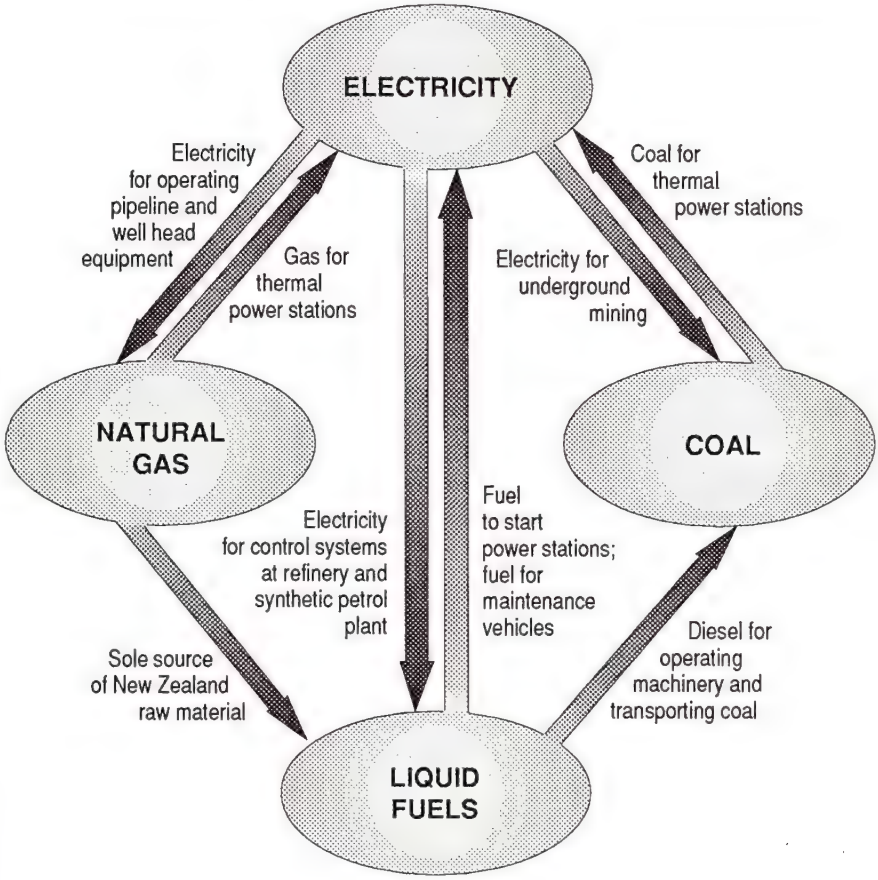
Changes in the supply of energy

There would be no foreseeable *physical* impacts on the energy supply systems in the first few weeks, although they would be very vulnerable to the attitudes and behaviour of the people who run them. The electricity grid is a robust system and hydro-generation should continue for the first year or two without major problems. Thermal power stations require more maintenance, and irreparable breakdown would occur over some decades. This would mean the loss of 43% of the current North Island electricity supply. The thermal power stations may in fact be closed before breakdown occurred, in order to conserve valuable supplies of natural gas and fuel oil. This would leave the more industrialised and heavily populated North Island reliant on electricity produced by the hydro power stations in the South Island. The transfer of this power would be jeopardised by any failure of the Cook Strait cable. The present cable is

nearing the end of its useful life and might allow for full use for about five years from now and at half power for a further ten years. It would be impossible to obtain a replacement cable and major repairs would be extremely difficult without imported equipment.

The Maui platform could be expected to operate normally until spare parts could no longer be made or adapted in New Zealand. That breakdown point could occur after months or years, depending, as would everything else, on local engineering capacity. Loss of Maui would mean no gas for synthetic petrol (immediately reducing petrol supply from indigenous sources by 50%) and no gas for electricity generation, there-

Fig 6/ INTERDEPENDENCE BETWEEN ENERGY SYSTEMS



fore closing the thermal stations. The North Island electricity supply would be more reliant on the transfer of power from the South Island via the Cook Strait DC cable.

Distribution of gas through the pipeline system could be maintained for about five years without imports. The vulnerable points would be compressors and pumps. Household supply could have problems with parts shortages after six months.

At present, 55% of diesel and 35% of petrol supplies come from imported crude oil which is refined at Marsden Point. It is assumed these supplies would no longer be available after nuclear war. Diesel supplies would therefore be more restricted than petrol supplies. A policy decision to conserve gas, thus making more available for use as CNG for example, would reduce the supply of condensate to the refinery, and thus reduce further the amount of diesel produced. Conservation of gas would also reduce the production of petrol from the synthetic fuels plant. The outcome could be that diesel levels would be reduced from 45% of present local levels of supply to about 34%, and petrol levels from 65% to about 58%. Complex and difficult decisions would have to be made, since demand for petrol would also be high, arguing against a cut in synthetic petrol production. An additional factor would be how long it was calculated that the Maui platform was likely to last since any remaining gas would be unobtainable once the platform became inoperative. Diesel is strategically more important than petrol since it is essential for the movement of food, manufactured goods, etc, via heavy road transport, railways, coastal shipping, and for off-road uses such as farming and construction. If railways and coastal shipping continued to receive their present levels of supply, the balance left for road users would be 22% to 33% of current levels. Road users now consume 75% of diesel supplies. Thus road users would be reduced to 30% to 44% of current levels of supplies. This severe reduction in diesel levels would necessitate strict rationing and a system of priority use. Petrol availability would be at about two-thirds of present levels.

This is the "best case" outcome and omits some important considerations. Loss of just the Maui gas supply would mean the smaller gas fields would be the only source for the synthetic fuels plant, thus dropping petrol supplies to about 30% of present levels. Diesel levels would be reduced to even more critical levels. If nuclear war occurred around the year 2000, remaining fuel levels would be approximately halved anyway,

even assuming Maui supply was unaffected. None of these figures allow for breakdown in equipment, either at the very complex synthetic petrol or the refinery plants, nor do they allow for major disruption to electricity supply. After nuclear war these disruptions would be likely to happen.

Availability of CNG and LPG

CNG (compressed natural gas) is a gas product that is presently used in 100,000 petrol-engined vehicles (approximately 6% of cars and light goods-service vehicles). It uses only 3% of current gas supply and since it does not go through any complex refining, CNG would still be available in quantity even if Maui or the refinery failed (Fig 7). CNG is delivered by pipeline to North Island vehicles only.

LPG (liquified petroleum gas) which is available in both islands and currently used in about 40,000 vehicles, would be less vulnerable than petroleum fuels to the breakdown of complex petrochemical plants.

Maintenance problems

Long-term maintenance would depend on the skills of local engineering firms. Recycling, repairing and substitution would be essential, both of the energy system components, and of engineering equipment which is largely imported. Basic components from ball-bearings to wire, tube, alloy steel and lubricating oils are all imported; the capacity for local substitution is limited and would take time to develop. Quite often small items can cause the problems. The hundreds of small consumable items in any workshop, from solder to drill bits, are often imported and increase the vulnerability of systems to break down.

Both the refinery and synthetic petrol plant rely on imported parts such as valves, pumps, heat exchanges and electronic instrumentation. Given their unique features, both plants have limited options to cannibalise other systems. Both plants also rely on imported catalysts (replaced every two to three years). The Liquid Fuels Trust Board suggests that workable, but less efficient, catalysts could probably be made in New Zealand given one to two years lead time. However, the Synthetic Petrol plant could run for only about two years before it would be necessary to close half the plant in order to provide spares for the continued operation of the other half.

POST-WAR ADJUSTMENTS

Assuming the initial shock and despair did not precipitate total panic and chaos in the community, fuel and electricity supplies might not be disrupted in the first few critical weeks after nuclear war. An early decision by government to clamp controls on all fuels might therefore be unnecessary and even counter-productive. Prompt curtailment of petrol supplies may not be needed. One danger of hastily-imposed rationing systems is the higher likelihood of their being flawed and hence not accepted. Rationing of CNG and LPG would be unnecessary. Controls and a system of priority-use for diesel and fuel oils would be the most urgent requirement. The allocation of diesel to "essential" services – such as food production and distribution, patrol/repair of transmission lines, maintenance of the emergency generators on the Maui platform, water supply and sewage disposal, emergency services, railways and New Zealand-wide shipping – would be a difficult task without prior planning.

Other immediate tasks along with decisions on rationing and priority uses would include combined stock-taking by government and essential industries of refinery products, LPG, coal stockpiles and key spares for each energy sector.

A new plan for the subsequent use of natural gas would be an early priority to ensure the best long-term use of New Zealand's most valuable fuel resource. Present economic criteria for decision-making on resource use would no longer apply. A primary objective would be to use the gas to buy time until sustainable, indigenous liquid fuels could be developed and utilised.

The aluminium smelter, methanol plant, many freezing works, and other plants supporting export-related industries would probably be forced to close, some immediately and permanently, others within a few years. It is important to plan shut-downs, either to protect the components for later use elsewhere, or in case they are required to re-open.

It would be important to implement conservation and recycling strategies. Energy conservation (meaning improved efficiency and less waste) is well understood, but poorly practised. Without prior planning and education it would take some time to become widely established but the incentive to do so would be high. Recycling could prolong the life of many materials and products. Three immediately important materials to conserve and recycle would be lubricating oils, copper (for electrical uses)

Fig 7/

NATURAL GAS PIPELINES AND SOME MAJOR ENERGY FACILITIES IN THE NORTH ISLAND

The wide distribution of natural gas throughout the North Island gives it potential as a major fuel for direct use by vehicles and for heating. Electricity generating stations are not shown.

and lead (for batteries). Most metals can be recycled in New Zealand and the capacity to do so could be expanded.

Long-term losses would have less impact if substitution programmes were implemented. The impact of drastic shortages of petrol could be reduced if more vehicles were converted to CNG. The conversion kits are presently imported, but could probably be made in New Zealand. However, with post-nuclear war shortages and no prior planning, conversion rates would be slow and difficult. Wood could be used more widely for home heating and cooking, and also as a material to replace some imports, in coal mines for example.

Long-term options for developing alternatives to replace failing technologies would include the commercial development of alternative fuels to petrol and diesel. Methanol could either be blended with petrol or used straight as a fuel. The feasibility for using methanol in diesel engines in post-nuclear war New Zealand has not been studied. Methanol is also the key to using some agricultural products (of which there could be a surplus) as diesel substitutes. Tallow from meat works, butter and rape seed oil can all be esterified with a small percentage of methanol to produce acceptable diesel substitues, or to blend with diesel. Another alternative could be to return to the technologies of obtaining various types of hydrocarbons from New Zealand's extensive coal reserves. Production of coal gas, for instance, might be able to be increased.

Solar technology would also be a priority for further development, because of its potential for water and space heating. Efficient, New Zealand-designed, solar water heaters which need no copper are now made in Christchurch. Solar heaters would gradually substitute for some of the present electricity load.

NUCLEAR WAR IMPACTS WITH AN EMP

The effects of an electromagnetic pulse (EMP) over New Zealand would be immediate and devastating. If New Zealand experienced an EMP the electricity grid would probably be overloaded with voltages that were two orders of magnitude greater than its design limits, causing short-circuits and permanent damage to insulation. Initial failure of the electricity grid would paralyse all other energy systems. The smelter would stop instantly, smelting pots would solidify and the entire complex would probably be written off. Sudden closure of the methanol plant might

make it very difficult to restart. The impact of an EMP strike on all energy systems is summarised in Table 4. No part of these highly interdependent systems would be unaffected.

The large complex energy installations (refinery, synfuels plant) would be particularly vulnerable because of their reliance on electronic control systems which would be destroyed. The outcome could well be the loss of the capacity to produce all petrol and diesel fuels in New Zealand. Since New Zealand sold its strategic reserve of 48,000 tonnes of diesel in January, 1987, only normal stock levels would be available and these would not last long, even with strict rationing for essential use.

TABLE 4: EMP EFFECTS ON ENERGY SYSTEMS

ENERGY	*SYSTEM IMPACTS*
Electricity	Immediate total loss of all supply. 20% – 30% restored in two to ten days. Perhaps 40% – 50% restored after one year.
Natural Gas	All production and distribution stops. Partial production possible after repairs. Recovery slow. Fire and explosion hazards from air leaks.
Synthetic Petrol	Plant immediately inoperative. No recovery possible.
Refinery	Immediate closure. Very limited repairs possible, with some petrol and diesel production.
CNG and LPG	CNG available when gas production resumes and distribution is restored. Resupply of LPG more difficult, but possible depending on transport and filling equipment.
Liquid fuels	All local sources of production immediately lost. Degree of recovery not certain, even if gas available. Future supplies could be extremely low.
Coal	Underground mines closed without electricity. Labour could replace mechanised equipment. Stockpiles of six months supply normally available.
Petrol distribution	Electronic petrol pumps would be inoperative, creating access shortage. Hand pumps required.

THE EFFECT OF AN EMP ON ENERGY SUPPLY

Most of the necessary adjustments, such as rationing fuel, would be impossible after an EMP strike. Lack of communications and power would prevent centralised control over resources, make stock-taking difficult, and would not allow for the development of equitable nationwide fuel rationing during the crisis phase. Concern for personal survival and safety would deter many people from going to work. Planned mothballing would be impossible. The orderly shut-downs of the aluminium smelter and methanol plant would not occur as outlined in the case of no EMP.

The restoration of power would depend on whether trained staff were able to make whatever repairs were possible using available spares. Without nation-wide communications, electricity workers would have little knowledge of what had happened and would, like the rest of the country, be in a state of shock and bewilderment, though linesmen are used to working in teams under disaster conditions.

Although 20% of capacity might be restored within two to ten days this would not be evenly distributed around the country. Power would be restored in ever widening networks, as sections of the national grid could be repaired. In any case, the loss of electricity for even one week would mean:

- All food in domestic fridges and freezers would thaw.
- Many shops and offices would have to close as lifts, lighting and other equipment would be inoperative.
- Meat carcases and other food in cold storage would thaw.
- Industries would shut down.
- Untreated water would enter city water supplies.

Batteries would become extremely valuable commodities, particularly as the raw materials used in their manufacture are not available in New Zealand. Although car batteries are rechargeable, the dry-cell batteries used in radios, torches, etc. are not.

The ability to move towards sustainable local technologies, using natural gas as the intervening fuel source, would be severely hampered. Methanol would probably be unavailable as a fuel alternative. Social conditions would be much less likely to favour the development of alternative technologies.

Without the restoration of gas production and with a limited capacity for CNG and LPG use, most transport in New Zealand would revert to sail, horse, bicycle and foot.

It cannot be predicted exactly what energy supplies would be available to consumers. The interdependence of energy systems is such that availability would depend as much on what planners do now, as on what decisions were made after a war, as well as on supplies of imports, people's behaviour in relation to using scarce resources, and the ability of engineers to adapt to difficult circumstances.

POLICY ISSUES

Planning

The "best case" for New Zealand's energy systems in the event of nuclear war has been analysed earlier in this chapter, i.e. no nuclear missile strikes or EMP effects on New Zealand, and maximum self-reliance in liquid transport fuels. Even under these conditions the outcome would not be reassuring: diesel immediately in short supply, petrol production down substantially and, after six months, the possibility of a steady decline in the reliability of electricity supply, coupled with sudden losses in gas and liquid fuel facilities.

If decisions about electricity, gas and coal were made independent of each other, there could be chaos in energy supply. There is a strong case for co-ordinated decision-making.

The analysis points clearly to problems that will need to be faced anyway, irrespective of nuclear war planning: exhaustion of the gas fields and the transition to substitute fuel sources when gas and imported fossil fuels run out. Therefore, the proposals below have a relevance beyond mitigating the impacts of nuclear war.

Several strategies would ease the process of transition to more efficient energy use and away from reliance on the vulnerable fuels, petrol and diesel. Expansion of recycling industries and energy conservation programmes would reduce import costs in peace time, extend the life of local supplies of metals and other materials, and strengthen New Zealand's capacity to cope with nuclear war or indeed any major supply crisis. Existing recycling industries could determine their potential for expansion and the likelihood of key shortages after a war.

Any large-scale transition to CNG use in vehicles would be much easier to accomplish if planned in advance. The capacity probably exists in New Zealand now to make all the components, but it would be advantageous to assess this potential now and identify key materials.

Research to develop alternative fuel supplies from indigenous resources, improve solar technology and develop more energy-efficient processes would be in the national interest.

The refinery and synthetic fuels plant are vulnerable to trade losses (reliance on overseas parts), EMP effects (electronic control systems), and loss of gas or electricity inputs. Increased resilience and the capacity to recover from disruption or disaster would be achieved not by stockpiling spare parts, but by making end-users less dependent on these two plants. Using more gas to directly fuel cars and trucks would reduce the dependency on the synthetic fuels plant and the refinery. This would also reduce New Zealand's technological dependence on Northern Hemisphere supplies.

A wider issue is the trend away from older, more manual technologies to high-technology innovations that are usually imported. Older technologies are more resistant to EMP effects, more likely to be made or repaired in New Zealand, and are therefore more likely to survive after nuclear war. In brief they are more resilient.

A return to resilient technologies would require planning for import substitution. Rather than stockpiling surplus spare parts of new machinery, it would be cheaper and more effective to identify viable processes that could substitute for imports in key areas. Production manuals and knowledge of the appropriate skills should be identified.

Inventories and research

Resource and parts inventories would improve post-war decision-making on rationing and priority allocations for fuels, labour and other resources. This would require industry and government co-operation and planning. Stockpiling of some key components or equipment widely used and not made in New Zealand could be considered and costed. The trade-offs between present costs and benefits to national security would need public discussion. The resilience of New Zealand's industrial and manufacturing capacity to major shocks is not known. The interdependencies between sectors are complex. These links may aid recovery or, like mountaineers on a rope, pull the whole system down together. It would be a valuable undertaking to assess these industrial interdependencies with the objective of building more resilience into the whole industrial base of New Zealand.

DISRUPTIONS TO TRANSPORT SYSTEMS

TRANSPORT IS AN INTEGRAL PART OF OUR LIVES and can easily be taken for granted. When asked, in a survey, what the problems would be in New Zealand after a nuclear war, people generally thought transport would be one of our lesser worries (Appendix 1) yet, after North Americans, New Zealanders have the highest ratio of motor vehicles to population, one car for every 2.2 people, and the threat of a petrol shortage can produce a rush on petrol stations and "Sold Out" signs. Overseas trade depends on ships and internal travel and movement of freight depends on road and rail transport.

NUCLEAR WAR IMPACTS

The shortage of fuel

The major impact on transport systems, as detailed in the previous chapter, would be fuel shortages. Initial panic buying would lead to local supplies of petrol being quickly exhausted until further shipments arrived from Marsden Point; however, supplies from Marsden Point would be cut to about 60% of present levels because of the loss of imported crude oil from which 40% of petrol is produced.

Diesel production would be down to 35-45% of present levels due to loss of imported crude oil (Chapter 9) so major problems of allocating remaining diesel to high priority users would rapidly arise. Many users would assume their requirements should have priority – trucks hauling food to cities, emergency service vehicles, Cook Strait ferries, food proces-

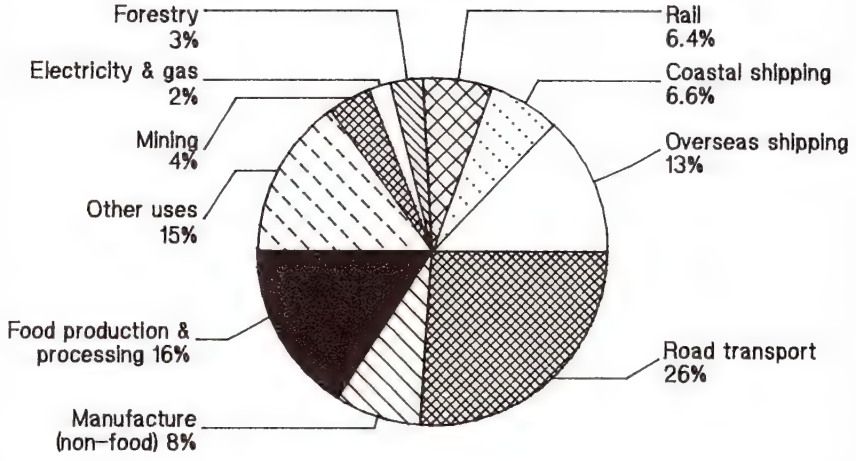
sors and manufacturers, generators for standby needs, rail for freight/food haulage. There is no immediately obvious mechanism for resolving issues of priority for any of the major transport fuels (Fig 8). If energy-efficiency were the main criterion, rail and coastal shipping would receive priority, but complementary forms of transport such as trucks, would still be needed.

When the end uses of diesel and petrol are compared (Figs 8, 9) the particular problem of diesel allocation and setting rationing priorities becomes clear. Although petrol is mostly used in road vehicles, half the diesel supply is used in non-transport activities such as manufacturing and food processing. Given this diversity of end uses diesel is a particularly important fuel and its effective rationing would be doubly important. Without an effective system of allocation, the potential for fuel wastage, uneven supply, and shortages would be high.

The North Island rail network should not be badly affected by fuel shortages since electrification of the main trunk line (due for completion in 1988) would give greater independence from diesel. Both shipping and

Fig 8/ END USE OF DIESEL (1985)

In contrast to petrol (Fig.9) diesel is used by a diverse number of sectors of which only about half are related to transport.

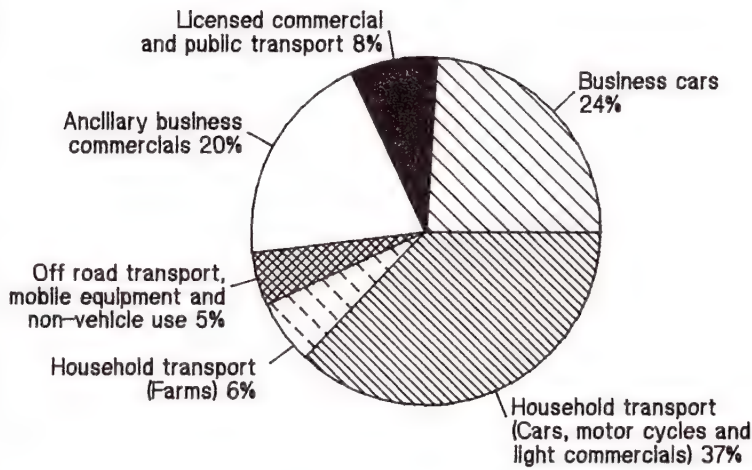


Source: Beca Carter Holdings & Ferner, Energy Use In Transport Data Report, 1986.

aviation would be badly affected. While smaller ships and fishing boats use diesel, larger cargo ships, including the Cook Strait ferries, burn heavy and light fuel oils both of which can only be refined in New Zealand from imported overseas crude oils. Aviation fuel is imported and there is usually a minimum of two months' stock at present levels of usage. Aviation fuel would need to be severely restricted to essential purposes. The present level of air travel would be drastically reduced and the rail ferries would be an essential link for people and freight between the North and South Islands.

Supply of fuels beyond the first few months would depend on several factors: the ability to obtain sources of crude oils from overseas, the ability of New Zealand engineers to keep the major energy projects going through local improvisation, the effectiveness of fuel rationing through a transition period (first year), and the speed with which alternative fuels could be brought into wider use. The successful integration of all these factors would be difficult to achieve and would require a great deal of co-operation between private and public sectors.

Fig 9/ **END USE OF PETROL (1985)**



Source: Becca Carta Hollings & Ferner, Energy Use In Transport Data Report, 1986.

Loss of spare parts and other imports

The crises over fuel supply would not be the only problem. A major problem would be a lack of lubricating oils for all engines – cars, trucks, tractors, ships, trains and aeroplanes. At present, almost all lubricating oil is imported, with sufficient stockpiles for only two to three months. The reliance of all transport on lubricating oils means the lack of supply would rapidly become an issue of national importance. Providing the refinery at Marsden Point could continue to operate it could produce lubricating oils from local crude oils. Lubricating oils can also be "cleaned", i.e. the impurities removed and the oil recycled for repeated use. A small amount of such recycling now occurs in New Zealand, but much greater capacity would be required. How rapidly these adjustments could be made is not known.

Another obvious concern would be the loss of the supply of imported road vehicles, either fully or partially assembled. The number of vehicles would steadily decline to a small percentage of the current number. Cannibalisation for parts would be the only way of keeping many vehicles running.

Declining use of road vehicles would be accelerated by the inability to manufacture new tyres and spark plugs. New Zealanders replace about 8,000 tyres every day with tyres made locally from synthetic rubber mixed with a small amount of natural rubber. Both ingredients are imported. Stockpiling tyres would be of limited long-term usefulness since the shelf-life of a tyre is relatively short. The assembly and manufacture of spark plugs in New Zealand relies on ceramics imported from the USA, and imported electrodes. The present stock of spark plugs (sufficient for one year's use at current rates) could be made to last longer, if plugs were carefully cleaned and their electrodes re-filed, but shortages would eventually occur.

Road maintenance would be hampered since bitumen is presently made from imported heavy crude oil. Manufacture might be possible from some local oils but scarce oils would probably be needed to produce fuels instead. Road maintenance would depend on using coal-tar and gravel.

Lack of spare parts would affect other transport systems. Few spare parts for aircraft are held in New Zealand. All parts for general maintenance of aircraft and for all communication and radio navigation facilities are imported. Eventual loss of navigation aids would reduce aircraft to

flying by visual flight rules (if aviation fuel lasted that long). Ships would be hampered by lack of spare parts for propulsion units which are made overseas from high quality steel.

An indirect, longer-term problem could arise from the lack of anti-corrosive paints which are necessary to stop rusting and other corrosion. Regular painting and overhaul of the Cook Strait ferries and other vessels, maintenance of the 2600 bridges and viaducts on the railways system and of the Auckland harbour bridge are all necessary to keep trains, ships and cars moving.

DISRUPTIONS CAUSED BY AN EMP

If an EMP affected New Zealand, the transport system would very quickly be seriously disabled, particularly because there would not be time for transition to alternative fuels and transport arrangements. Marsden Point refinery and the synthetic petrol plant would be severely damaged or inoperative and the resulting abrupt loss of fuel manufacturing capacity would mean that petrol and diesel stocks would diminish to the meagre amounts in storage at the time; barely enough for one to three weeks' use at current levels. Given the chaos in communications, it would be very difficult to impose rationing quickly enough to slow the use of these stocks.

Loss of electricity would force people to pump petrol by hand from service station storage tanks. After those stocks had gone there would be no more supplies since the synthetic petrol plant would be inoperative, and the oil refinery barely functioning. CNG might eventually be available to North Island cars, though it would be difficult to supply without electricity for compressors. Another problem would be that some of the cars presently converted to run on CNG have electronic ignitions which would be damaged by an EMP. Any vehicles that could operate would not be evenly distributed throughout the North Island and would not be an immediate answer to the lack of diesel for rail, ship or truck requirements. Main trunk rail would not have electricity supply because of damage to the national electricity grid, and to its own systems, including the signalling systems.

The impact of a nuclear war on New Zealand's transport system would therefore be completely different if the country experienced an EMP. Instead of cars, trains and ships continuing to operate, albeit at a reduced capacity, there would be a rapid run-down and collapse of organised transport throughout the country, probably within a month. The loss of

transport would be felt more severely in the cities as supplies of fresh food failed to arrive and the main forms of transport reverted to bicycle or foot.

POST-WAR RESPONSES

After a nuclear war there would be an urgent need to prevent wastage of supplies. Resolving issues of allocation and maintaining an equitable rationing system would be a high priority until alternative fuel systems were available. Rationing would reduce wastage, as would more energy-efficient use of fuel. Public transport uses fuel more efficiently than cars, and rail is more efficient than road. Coastal shipping could be expanded although the present fleet is small (16 vessels, including three ferries) and designed for carrying specific products (e.g. oil, cement). The unscheduled arrival of overseas cargo vessels could alleviate this problem. Bicycles could be used for moving goods as well as people (as happens in Asian countries today). Priority use of rubber stocks might well be for bicycle tyres and tubes rather than car tyres.

Rapid expansion of recycling industries including re-use of lubricating oils would be required. Re-use of lead for new vehicle batteries would be important as would the general retention of "throw-away" items for alternative uses.

As well as the alternative fuels options discussed in Chapter 9, a shift in relative use of different transport methods, more use of rail and less use of cars for example, would be required to overcome the lack of imports. New alternatives to lubricating oils would be a high priority. New Zealand would be well placed, given its livestock and dairy products, to exploit existing technologies that produce lubricating oil from butter fat and tallow. None of these options would be rapid and could be difficult to implement after nuclear war. Re-use of steam locomotives would be a limited option. Only 15 are currently working, with a similar number restorable to working order. These 30 locomotives would represent only 10% of the number of more powerful diesel/electric locomotives currently in service.

Limitations of transport would provide pressure for a re-orientation to regional rather than national activity as people sought goods and services from local or regional sources.

If an EMP affected New Zealand, the pressures for all the above

adjustments would be even greater, especially the need to develop alternative fuels, methods of transport and local self-sufficiency. However, the ability to make such adjustments could be extremely limited and their development might be haphazard and localised.

POLICY ISSUES

Any allocation or rationing plan for fuels that did not rely on force for its implementation would need to be developed in conjunction with all affected sectors and to have public acceptance. Such planning would be difficult if left until the crisis conditions of a nuclear war or even immediately pre-war. The fuel rationing scheme of the 1970s was unpopular in part because some interests were felt to be unfairly favoured. Pre-war planning would not need to be detailed, but could establish broad principles from which lower-level decisions could be rapidly worked out depending on the particular circumstances that applied at the time. Ideally, a rationing plan would also allow for some buildup of a national reserve given the likelihood of production failure as breakdowns at the energy complexes became more likely.

New Zealand's dependence on diesel and petrol could be lessened by the conversion of more vehicles to CNG and LPG. Developing the capacity to produce the necessary conversion kits entirely within New Zealand would further strengthen the country's capacity to cope with a sudden or longer-term loss of crude oil supplies. Stockpiling diesel and petrol, while not a long-term solution, would alleviate problems in the crisis period. Expansion of recycling industries would also lessen the dependence on imports. Research into the viability in New Zealand of the guayule shrub (which supplied 10% of the world's natural rubber in 1910) could lead to the establishment of an important local source of rubber. More research into alternative fuels could be undertaken and research links with Australia on these topics would be of mutual benefit.

INITIAL IMPACTS ON THE FINANCIAL SECTOR

IMPACTS THAT HAVE ECONOMIC IMPLICATIONS run through most of the chapters in this report. However, some issues pertaining specifically to the financial sector are examined here. The financial system can be seen as the oil which lubricates the economy. It is defined here to include merchant, trading and savings banks, stock exchanges, investment and pension funds, insurance companies and building societies. It is closely linked to government which controls the amount of money in circulation and sets rules for the activities of the financial institutions. Government is also a major influence on the financial system through its own expenditure, taxation and borrowing requirements.

Money is the basic component of a financial system. It provides a medium for complex exchanges between what people have to offer, and what people require. For example, an exchange of wheat for meat between two farmers over the back fence requires no money. However when a farmer has produce to offer, and wishes to acquire petrol, the chain of distribution between the oil well, the refinery, the tanker and petrol station is too complex to allow for a barter arrangement. Money overcomes the problem of having to arrive at mutual trade by acting as an intermediary unit of exchange.

The financial system which has developed to cope with the complex exchanges of goods and services within New Zealand and with the rest of the world, is becoming increasingly sophisticated. Disruptions to the financial system would affect the patterns of exchange, and *vice versa*.

IMMEDIATE IMPACTS

Immediately after nuclear war, people in the financial sector would be experiencing the same horror and anxieties as other people. Maintaining normal operations might be impossible for at least a few days. In fact, the initial uncertainties might cause the banking system to close immediately for all withdrawals, credit, cheque clearance and electronic transfers (e.g. salaries). This would allow some days to sort out internal problems and avoid a run on withdrawals as people tried to obtain cash and recover savings. Closure of banks at such a time of crisis would increase people's anxieties considerably. This sudden lack of confidence in the financial system could cause a downward spiral into economic depression.

The financial sector is now extremely dependent on electronic calculation, transaction and recording systems. Databank computers process 95% of all cheques issued in New Zealand. A high proportion of salaries and wages are paid through computer systems. These operations rely not only on computer systems and parts, supplied exclusively from the Northern Hemisphere, but also on electricity, fuel for stand-by generators and telephone circuits that link computers in different centres.

An electromagnetic pulse (EMP) would instantly cripple these services and make computers inoperative. Transactions that were being made at the time would be irretrievably lost unless there were manual records as well. Information stored on disks and magnetic tape might survive an EMP, but would be unavailable unless there were operational computers. The entire banking system would be forced to close while it sorted out alternative manual systems. How long this took would depend largely on whether staff returned to work amidst the general disorder, the extent of collapse of electronic systems, and uncertainties over personal security and their employers' ability to provide income.

Bank closures would affect commercial activity as well as individuals. The difficulty of making cash payments would create severe problems for paying workers as well as for commercial activity. Extensive credit arrangements would be needed although the economic uncertainties would make these difficult to sustain without a high degree of economic confidence, and it is very unlikely that confidence would be high.

CONSEQUENCES OF UNCERTAINTY

Even if no EMP occurred and records of balances and transactions remained accessible, such records would have little meaning as the relative values of assets would be uncertain. For example, what would be the value of shares, mortgages, commercial bills, pension and insurance contracts? It would be difficult to compare the value of assets such as meat processing works, city office blocks and luxury apartments with the value of an old house on a large section with fertile soil. Some previously valuable assets would be instantly worthless (e.g. Northern Hemisphere investments), others would be very valuable (e.g. cars fitted for CNG). Financial institutions, many with substantial overseas investments, could experience a substantial shift in the balance between assets and liabilities and would be unable to operate effectively. For example, their assessment of their revised net worth (i.e. assets minus liabilities) would greatly influence their solvency and hence future lending and trading decisions.

Increased public uncertainty could lead to excess demand for the withdrawal of savings. This would put pressure on banks which might not be able to provide the funds. The choice would have to be made between meeting these demands, or freezing the accounts, to enable an assessment of the situation and make positive adjustments.

Rapid and extensive changes to relative prices and the value of assets would be most unlikely to facilitate a fair or desirable distribution of vital goods and services and purchasing power. However, that fairness would be essential for maintaining order, social cohesion and productive activity.

Demand for money would be unpredictable. Some people would try to hoard as much cash as possible, others would doubt its value and would rely on direct barter exchange, or hoard scarce goods as their store of wealth. Uncertainty about the future would make investments and borrowing risky and difficult. The credit systems now taken for granted could not be maintained. That change alone would have pervasive impacts.

POST-WAR ADJUSTMENTS

Financial systems evolve hand in hand with economic activity. The character and complexity of a post-nuclear war financial system would be shaped by post-war society and the degree of recovery in productive economic activity. It can be assumed that following a major nuclear war the

financial system would suffer immediate disruptions. How long it would take for a new system, albeit on a smaller and less sophisticated scale, to become stable would depend on the nature and extent of continuing economic activity, on the stability of the society, and on confidence in the future.

The degree of financial disruption and the extent of the recovery period could be influenced by government action. If government had public and private sector support for its efforts, and was able to maintain a degree of confidence and cohesion in the early post-war days, it might be possible to moderate the degree of financial disruption and chaos. Government action might include a general supporting role through the Reserve Bank making cash available to the financial institutions and with a government guarantee of deposits. This might be sufficient to stem a currency panic. Government would have to act swiftly and effectively and make the correct decisions in the early post-war days under conditions of extreme crisis management (see Chapter 16). If there were an EMP it is highly unlikely that such decisions could be effectively implemented given the general breakdowns that would occur.

On the assumption that there were no EMP-caused disruptions and government and society survived the first month, there would still be major disruptions to parts of the financial sector. Institutions such as stock exchanges would be so massively affected by changing values and prices that their collapse would be highly likely. Some banks, probably the larger existing trading banks, might survive but others would not. The ability of government to provide financial support to such institutions would be restrained by the loss of export markets and rapidly rising unemployment. However, other forms of government intervention, such as regulation and rationalisation of the financial system, could still be useful for limiting the effects of the crisis.

Even if the problems created for the financial system and its relationship with economic activity were contained, it is much less likely that the financial system as a whole would re-adjust in the long-term to anything like its pre-war structure. The loss of exports and imports with their associated markets and trading patterns would greatly alter demands on the financial sector. Given the interdependence of trading and finance, these long-term disruptions in the economy would alter the functions and structure of the financial system.

The financial system would remain in chaos longer if there was

extensive social breakdown which hindered productive economic recovery. This would be more likely following the disruptions caused by an EMP. If there was no stable future to look forward to, people would find little incentive to save and invest, thereby diminishing the need for many of the existing financial institutions. "Adjustments" in this case would occur by painfully slow steps, possibly through the development of effective barter systems and then back to some form of monetary system.

POLICY ISSUES

In consultation with the financial institutions government might be in a position to moderate the adjustment processes. Pre-war planning among financial institutions, including government and the Reserve Bank, to formulate some co-ordinated measures for the initial crisis period might well be worthwhile. Measures to consider include: an orderly closure of financial institutions for some days while records and operating systems were sorted out; development of stand-by manual procedures; agreement that all deposit liabilities would be jointly guaranteed by the institutions and the government; the feasibility of replenishing banks with "sufficient" cash; agreed procedures for the orderly adjustment of assets and liabilities in balance sheets, development of EMP-protected storage and computer systems.

ECONOMIC DISRUPTIONS FOLLOWING LOSS OF TRADE

THE PREVIOUS CHAPTERS HAVE SHOWN that much of New Zealand's economy is directly, or indirectly, dependent on trade, predominantly with the Northern Hemisphere. Imports, whether of raw material supplies or of small but essential components, are vital to many industries. The level of activity in many sectors is also dependent on exports (e.g. the production, processing and transport of food and fibre). Even in areas where there is no obvious dependence on either imports or exports, e.g. roading, hydro-electricity generation or local authority activities, there is indirect dependence on products with imported elements, or demand generated by overseas earnings.

Conventional measures of dependence, such as estimates that about one-third of GDP comes from trade, substantially understate the full structural impact of the loss of external trade. Essentially the structure of New Zealand society, of where and how people live and what they do, has developed from an historical pattern which pre-supposes a high level of exchanges with the rest of the world.

NUCLEAR WAR IMPACTS

Over 80% of New Zealand's trade is with Northern Hemisphere countries. A major nuclear war, coupled with "nuclear winter" effects on combatant and non-combatant countries, would effectively end that trade and severely disrupt trade with Southern Hemisphere countries.

Immediately after a nuclear war, supplies of many raw materials, components and products would be limited to stocks on hand; and every export industry, along with all its services and infrastructure, would be under threat. In the long term there would be some potential to find alternative Southern Hemisphere sources or substitutes for imports and to develop different markets or alternative uses for the resources used for exports. Meanwhile, there would be a long period of shock and adjustment on a scale far beyond any economic depression New Zealand has experienced.

It is difficult to trace the path of the shock – beyond saying that those who are directly involved in importing or exporting would be among the first to feel it; that it would extend to those whose activities *seem* to rely on the domestic economy, e.g. timber workers whose raw material comes from and will be used in domestic activity but whose chainsaws and other tools depend on imported machinery and components; and that it would reach to those who feel they are not involved in "the economy" at all.

If, as discussed in Chapter 11, this shock to the physical economy were accompanied by collapse in the financial system and the money economy that enables complex transactions to be made, the shock would be transmitted more quickly and sharply. Sooner or later the loss of trade would have a substantial impact on everyone living in New Zealand.

While accurate estimation of the impacts is not possible, their order of magnitude can be indicated by simple measures which are described in Background Paper 17. Even if trade with Southern Hemisphere countries could be restored quickly, New Zealand's dependence on Northern Hemisphere sources of imports would have substantial effects across all sectors of the economy – primary, manufacturing and services. Simple estimates of the effects on employment from the loss of imports from and exports to Northern Hemisphere countries and from consequent reductions in domestic demand indicate that employment might fall by about 40-50%. In recent years unemployment has reached around 5%; in the depression of the 1930s it peaked at about 12%. It is difficult to imagine the

catastrophic impact of unemployment levels four times greater than in the depression, even if New Zealand's social structure coped with all the other impacts of nuclear war.

Quantitative economic estimates of the implications of trade disruptions have severe limitations. The loss of a million dollars worth of imports of cedar and mahogany for the construction and furniture industries might have little impact other than to limit the consumers' choice to pine. But the loss of a few thousand dollars worth of ball-bearings could immobilise vital machinery.

The reduction in imports would mean in economic terms that New Zealand would not need export earnings to pay for them, but how would the economy adjust to needing say 15 million sheep rather than 65 million? The adjustment process and the uncertainties surrounding it would be pervasive, affecting not only the farmers but the retailers, wholesalers, and bankers, the mechanics, topdressers, fencers, and accountants who supply their needs; the shearers, truck drivers, meat workers, scourers and wharf labourers who handle their products; and the traders, marketers, advertisers, printers and shipping executives whose incomes depend significantly on the sheep industry. Similar ripple effects would be felt through all other export industries – beef, dairy, apple, kiwifruit, fishing, forestry, paper and many manufacturing industries. All jobs in private sector servicing industries would be affected by these uncertainties and there could be no security in the public sector as the role of government and its ability to finance its activities would be undermined.

There would be a rise in demand for manual labour to compensate for failures of labour-saving technologies and energy systems. But new systems for organising and paying for that labour would need to be developed.

While many of these effects would not occur immediately, it would very quickly be obvious that they were going to occur. Even without an immediate collapse of law and order or of the financial and money systems, uncertainty would quickly affect the lives and behaviour of everyone in the workforce and all those dependent on them.

EMP disruptions would add significantly to the "immediately unemployed" total and could well signal the end of the formal market economy. Without electricity, output and employment in many sectors would fall rapidly and industries would have to close. The effect of an EMP would hasten and exacerbate all the disruptions and uncertainties discussed above.

SOUTHERN HEMISPHERE TRADE

One of New Zealand's largest trading links is with Australia, accounting for about 17% of all imports and exports. It is New Zealand's most important trading partner in the Southern Hemisphere accounting for 79% of all Southern Hemisphere imports. Under Assumption 6a (Chapter 1) it was assumed that reduced levels of trade with Australia would be possible, but under Assumption 6b, with wider destruction of military bases, cities and a disabling EMP, trade between the two countries would collapse. Maintaining a trading link with Australia would, at first glance, appear to be of particular importance for New Zealand after nuclear war.

However, two factors affect this conclusion and would diminish the "assistance" New Zealand might expect from ongoing trade links with Australia. First, the Australian economy, like that of New Zealand, is closely integrated with the rest of the world. That integration is particularly strong with the EEC countries, USA and Japan which supply almost 70% of Australia's imports.[1] Further, about 60% of those imports are machinery, petroleum products, transport equipment and chemicals; items that constitute a critical part of the capital equipment, essential materials and fuels for the Australian industrial system. Forty percent of Australia's automotive and industrial diesel oil and fuel oil is refined from imported crude oils. Lubricating oils would run out in about four months without rationing.[2] Without alternative sources the Australian industrial system would grind to a halt.[1]

Thus the economic shocks experienced by New Zealand would most likely be experienced by Australia as well, for similar reasons. What trade would be possible, given such profound disruptions, is uncertain but it would probably be much less than before nuclear war.

The second factor likely to diminish trade between Australia and New Zealand would be the products both countries would have available for export and required as imports. Both would face the same crucial shortages which neither would be able to supply. Other items now traded would be of reduced value in post-nuclear war conditions. A comprehensive study of the impact of nuclear war on Australian society and environment would help clarify these disruptions and the likely level of trading activity that might be possible.

At best, New Zealand has tenuous trading links with other countries in Africa and Latin America which would be less severely affected than

combatant countries. Historically, New Zealand's trade routes have been to the Northern Hemisphere. New Zealand would face formidable problems realigning its trade after nuclear war.

POLICY ISSUES

The impact on New Zealand of the loss of external trade following a nuclear war would be pervasive and fundamental. A fully effective strategy to reduce vulnerability to these impacts would similarly need to be fundamental. It is not simply a matter of identifying a small range of particularly vital imports and encouraging domestic production of them: it would involve a total restructuring and reorientation of our economic and social patterns away from external trade, with the dramatically lowered standard of living that would result. Such a complete restructuring would clearly not be feasible as a precaution against the possible occurrence of a nuclear war. It is however feasible to examine the barriers to domestic production of some key imports such as pharmaceuticals, to estimate the additional costs of domestic production, and to encourage debate on whether New Zealanders are prepared to pay those costs in order to reduce New Zealand's vulnerability.

CHANGES TO THE NATURAL ENVIRONMENT

THIS CHAPTER DIFFERS FROM PREVIOUS ONES with respect to the time periods involved. Nuclear war would affect society immediately. By contrast, some of the changes postulated here would take decades to occur, while other impacts would only be felt over the first year or two. The only impacts on the environment which would be likely in the first month would be those resulting from human actions.

Two other general points should be noted. The changes in New Zealand's natural environment would be very much less severe than changes to the natural environment of other countries, especially those in the combatant zones. Some of the impacts on these Northern Hemisphere areas, as reported in the SCOPE report,[1] are summarised in Chapter 2. Secondly, the degree to which New Zealand would be affected depends partly on the time of year. New Zealand is most likely to suffer from decreasing temperatures, reduction of sunlight and air-borne pollutants following nuclear war during a northern summer. These environmental impacts are less likely after a northern winter war when less smoke is carried into the Southern Hemisphere.

Many diverse systems make up the natural environment, ranging from oceans, to forests and rivers. Each has particular vulnerabilities to nuclear war. The three systems in New Zealand that are most likely to be affected by a nuclear war are marine and coastal regions, lakes and rivers and forests. The influence of people on the environment may be the greatest environmental impact since nuclear war could directly change the present pattern of use of natural resources. Impacts on agricultural land were discussed earlier in Chapter 8.

CHANGES TO MARINE AND COASTAL REGIONS

The biggest impact on coastal zones would be from human exploitation and increased pollution. Coastal food sources such as shellfish could be severely depleted if there was a breakdown in food distribution systems

and a move to greater food self-sufficiency by coastal populations. The effects would initially be patchy and more severe near populated areas. If diesel supplies were not freely available for fishing boats, fish stocks would be less vulnerable and would increase in the long-term with the decline of local and overseas fishing pressure.

Increases in pollution levels from run-off into rivers, harbours and estuaries would heighten existing problems in places such as the Manukau Harbour. Although industrial pollution might decrease as export-related industries closed down (see Chapter 12), disruptions to sewerage systems in large urban areas would lead to discharge of raw sewage. Estuarine systems would be severely disrupted if such discharges continued for a long time and local shellfish would become a health risk if eaten.

Assuming New Zealand is not a nuclear target, the species most likely to be affected by radiation are migratory bird species that spend some months of every year in the Northern Hemisphere. The best known and most abundant of these is the sooty shearwater, or Southern muttonbird. Although it breeds in New Zealand, the Southern muttonbird and several other species of local seabirds live in the Northern Pacific during the New Zealand winter. They would be subjected to local and delayed fallout, lowered temperatures and a possible reduction of food supply. The potential disruption to their migratory behaviour is unknown. The outcome could be a severe reduction of muttonbird populations and consequently their loss as a food source for New Zealanders.

At greater risk would be the 26 bird species (e.g. godwit and knot) that breed in the Northern Hemisphere and migrate to New Zealand for the southern summer. A nuclear war during their breeding season would almost certainly kill all chicks through cold and lack of food. It is doubtful whether adults would survive the cold and find enough food for the long southward migration. At worst, most of these species of migratory birds could become extinct.

The amount of radioactive fallout likely to reach the seas around New Zealand is not considered to be great (Background Paper 9). The vast amount of water in the oceans would have a great diluting effect on any fallout that reached the sea from highly contaminated areas, and there would be no danger to people swimming off New Zealand's shores. The figures used to estimate the likely radiation dose to affect New Zealanders (Chapter 3) included a minute amount received by eating fish that had been contaminated by fallout in the ocean.

CHANGES TO LAKES AND RIVERS

Climate changes would have minor impacts on New Zealand's lakes, rivers, and freshwater species. The assumed temperature drops would mean a delayed thaw, less snow melt in summer and less run-off into South Island rivers and lakes, but the decrease would be unlikely to threaten the survival of river species.

If large quantities of airborne pollutants arrived over New Zealand then the acidity of rainfall would increase. However, acid rain would need to continue for a long period of time, probably years, to have serious effects on freshwater and soil systems. This would appear to be unlikely given present understanding of atmospheric effects.

Pollution of freshwater systems is most likely to come from uncontrolled discharges of domestic effluent (waste water and sewage). Whether this would be a temporary or long-term problem would depend on how society was able to maintain waste treatment systems.

CHANGES TO FORESTS

The possible temperature drops could significantly increase the frost period, especially in southern and inland regions (see Chapter 8). Frost-sensitive seedlings and plants growing at their southern geographical limits might be killed, but the loss of whole species would be unlikely.

Frosts, lower temperatures, less sunlight and increases in ultra-violet (UV) would all have the effect of stressing forest plants and reducing their growth rates. A drop in light levels of 20% would reduce tree growth, both in native forests and pine plantations, by about 25%. UV inhibits photosynthesis, affects fruit growth and yield, and pollen germination. These impacts may persist through a second year. Although the forest trees would survive these stresses it is likely that fewer flowers, and therefore fewer berries and native fruits, would be produced. The cooler summer temperatures and UV levels may also prevent some berries from ripening, thus reducing food output even further. Temperature drops would also reduce the abundance of native forest invertebrates (insects, spiders, woodlice, etc). The combined impacts of less food (flowers, berries and invertebrates) and colder temperatures would directly affect some forest bird species. The effect on individual species cannot be predicted, but the loss of birds would be possible. Temperature and food

conditions in the following winter would be critical for their chances of survival.

Bird species which are presently endangered (e.g. kokako, kakapo, takahe, Chatham Island black robin) would face an uncertain future. The public resources that now go into conservation and management programmes would probably cease. Endangered species could face the short-term problems mentioned above and in the longer-term their survival would be threatened by increases of those species that directly compete for the same food sources, such as possums, goats and deer.

These "pest" mammal species would cause more damage to native forests in the following decade than any of the short-term climatic impacts caused by a nuclear war. Apart from being a local food source, possums, deer and goats would suddenly cease to have value as export commodities. Control of these species, and of others such as pigs, rabbits and hares, would probably be low priority even if the resources were available. Consequently their numbers would increase over time at the expense of vulnerable native plant species that could be reduced to very low numbers or to extinction.

The long-term impact of people on forest resources would be uncertain though existing pine plantations should easily meet demands for building timber. The pressure to exploit native forests for conversion to exotic species would cease with the loss of Northern Hemisphere trade. On the other hand, patchy local exploitation of forests as a source of fuel or as building material would increase.

The worst outcome for native forests would follow from the occurrence of an electromagnetic pulse (EMP) effect. An EMP would, as explained in earlier chapters, drastically reduce energy supplies causing some urban people to move to rural areas where local resources can meet their basic needs. Under those circumstances demands for wood, both as a fuel and as a building material, would rise substantially because, for some people, wood would become the main energy source for heating and cooking as it is now in many Third World countries. The outcome, particularly in the more densely populated North Island, could be substantial utilisation of both native and exotic forests with an associated loss of habitat for a wide variety of native animals. In those difficult circumstances the present legislative and social constraints over use of forests would have little effect.

REFUGEES

AS A RESULT OF A NUCLEAR WAR and the vast devastation of their homelands, many people would be forced to migrate. While it cannot be estimated how many would reach New Zealand, even a very small number would pose problems that post-nuclear war New Zealand would have difficulty solving.

This chapter discusses some of the factors that would prevent numbers of refugees from arriving, and draws attention to the problems that could occur if only a few did arrive. Included in the discussion are the hundreds of thousands of people living in other countries who have a right to enter New Zealand and who may wish to do so *before* a nuclear war, and the tourists and other visitors in or near New Zealand (under normal circumstances numbering in the thousands) who could be "trapped" here if nuclear war occurred with little or no warning.

POST-NUCLEAR WAR REFUGEES

Refugees likely to arrive in New Zealand could include civilians, some armed, and military personnel. Many of them could be carrying diseases and have various degrees of radiation sickness. Their intentions would vary from seeking refuge, to bargaining for resources, to direct military conflict. After a nuclear war, crews of military vessels and aircraft might decide that their best chance of personal survival would lie in making for non-targeted territories (including New Zealand). However there are several factors, apart from the health of the travellers, that would make it difficult for refugees to reach New Zealand.

Factors preventing their arrival

Distance would be the greatest obstacle (see Fig 10). Even the countries geographically closest to New Zealand are still a long way away (for example Australia is over 2,000 km distant). Refugee vessels would probably be overcrowded and poorly provisioned, and therefore under tremendous pressure to make the nearest, safest landfall. Refugees from Europe, Africa, Asia and eastern North America might find it easier to reach Southern Hemisphere countries other than New Zealand. Refugees from Australia and South Pacific Island countries would have the easiest sea voyages. If Australian bases and cities were bombed there could be considerable numbers of people from Australia seeking safety in New Zealand.

New Zealand has strong historical, cultural and economic links with Europe and North America. Both these regions would be devastated in a major nuclear war. Attempts by survivors to reach New Zealand would be severely hampered not only by distance, but also by the destruction of ports, airfields and fuel stocks. The larger the war, the greater the destruction and the more difficult it would be to travel by sea or air. Another major difficulty for survivors in combatant countries devastated by war would be the organisational tasks of equipping vessels for long-distance travel - finding crew, fuel, food and other provisions. Long-distance air travel would be particularly hampered by the need for refueling stops and the reliance on ground support staff.

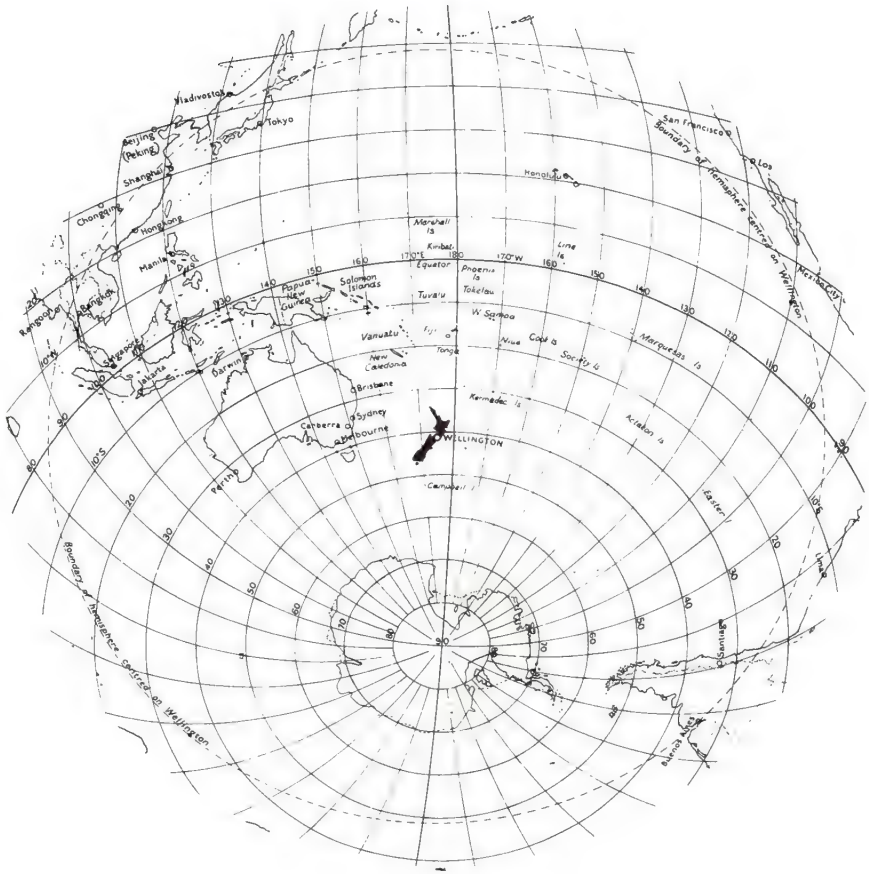
Another important factor affecting the numbers of refugees arriving in New Zealand is the policies and actions of authorities in countries of departure. Governments may prevent cargo ships from leaving with refugees, recognising the value of such ships for trade and freighting of essential materials. In combatant countries such control is less likely to exist, but in southeast Asian countries it could be a factor. In summary, although it may appear that there could be large numbers of potential refugees with the intention of going to New Zealand, there would be many constraining factors preventing their arrival, not the least of which is New Zealand's isolation.

Consequences for New Zealand

Notwithstanding the arrival of nuclear-armed vessels or surviving military forces, the most serious threat for New Zealand would be the arrival of refugees carrying infectious diseases. Even small numbers of refugees

Fig 10/
THE HEMISPHERE PROJECTION AS CENTRED ON WELLINGTON

The hemisphere centred on Wellington is dominated by vast expanses of ocean and great distances to major areas of population. Closest neighbours are Australia (2,000km) and the scattered island countries of the South Pacific Ocean. (Source: Map from Defence of New Zealand *Review of Defence Policy 1987.*



could establish pockets of infectious diseases. Some would bring diseases already present in New Zealand (hepatitis, tuberculosis, diphtheria), others might bring epidemic diseases now absent - plague, typhoid fever, cholera, typhus and leprosy.

Refugees arriving a year or so after nuclear war are more likely than earlier arrivals to be carrying infectious diseases since these diseases would have, under post-nuclear war conditions, established widely throughout the Northern Hemisphere, either by natural spread, or via migrants. The arrival of such diseases after, say, 6-12 months would find New Zealand in an extremely vulnerable position. Existing vaccines and other pharmaceuticals would be almost exhausted and adequate sources of supply or local manufacture to cope with major epidemics would probably not have been organised in that time. Well-organised quarantine facilities would be necessary in several parts of the country, depending on the numbers of refugees.

Large numbers of refugees would impose severe demands on basic services and would further overload a social system struggling to cope with local requirements. In peacetime, refugees can be housed, fed and supported by government and other agencies until they become financially self-sufficient. After nuclear war those services would be very heavily overloaded. Volunteer agencies would be fully occupied with social problems within local communitites.

Thus, the number of refugees that New Zealand could cope with easily after nuclear war is very small. Critical factors would be health-related issues, provision of quarantine, additional social stresses, and meeting basic requirements such as shelter.

PRE-WAR REFUGEES

There are other categories of people who may, inadvertently, cause problems for post- nuclear war New Zealand. For instance, if a nuclear war occurred with very little warning, there could be up to 45,000 people in New Zealand (1986 census) who normally live in another country. These include tourists, business people, students, ships crews, and embassy staff. If there were an extended warning time before an outbreak of war these numbers might either decrease, if people returned home, or increase, if people attempting to "escape" the war set out for New Zealand. Even if these "trapped tourists" were the only refugees in New Zealand they

would create significant demands. Forty-five thousand people is four times the annual number of permanent immigrants presently accepted into New Zealand (excluding returning nationals). Those without jobs would require employment and assistance although it is unlikely government would be able to attend to these demands in the first few weeks. "Temporary" accommodation could be provided in hotels and motor camps.

If they were able to return, the number of expatriate New Zealanders would be sufficiently large to cause a problem. Present estimates suggest there are up to 400,000 New Zealand citizens overseas, by far the greatest number of them in Australia (207,000 according to the 1986 Australian census), and 23,000 Tokelau, Cook and Niue citizens, all with legal right of entry to New Zealand (see Background Paper 18). Many of these expatriates would be unable or unwilling to return to New Zealand, but if a significant number of them did arrive during a pre-war crisis period they would strain housing, employment and social services. Not all would have New Zealand relatives to rely on. Also to be considered are the 16 million Australians who, under the present no-visa policy are allowed free entry into New Zealand.

PEOPLE IN TRANSIT

Crews of cargo ships would constitute the majority of the people in transit at the time of a nuclear war who could reach New Zealand. On any one day about 1,650 cargo ships (of over 5,000 tonnes) are crossing the Pacific Ocean, all of which would normally have sufficient fuel to reach New Zealand. During pre-war tensions there would probably be considerably fewer ships at sea, so assuming only 1,000 of these ships were at sea at the time of a war and 20-30% headed for New Zealand (other destinations would also be sought) the number of crew arriving would be about 8,000.

A smaller percentage of the 2,400 cargo ships normally crossing the Indian or Atlantic Oceans might also reach New Zealand. This would add another few thousand people, giving a total of around 15,000 foreign crew arriving in New Zealand.

Aircraft in transit in time of war might be able to divert to New Zealand, if they survived EMP effects. On any one day about 12 international flights arrive in New Zealand with a total of 2,600-3,400 people. Other flights

operating in the Pacific area would usually have sufficient fuel to divert to New Zealand if they chose to do so.

If it is assumed that between 20,000 and 50,000 New Zealanders (mostly from Australia) returned to New Zealand before a war began, then a rough estimate of potential pre-war and immediate post-war arrivals is possible. If 40,000 foreign nationals are included, the total number (including ships' crews) would be 75,500 to 105,000 people. These estimates may seem conservative, but they still total significant numbers of people for New Zealand to absorb. They represent from 2.7 to almost 4 times the largest annual flow of migrants that New Zealand has experienced in the last 25 years (28,000 in 1974). Furthermore, migrants normally arrive over a whole year, not in a short period of time.

ETHICAL DILEMMAS

The ethical conflicts inherent in the refugee issues were evident in the different replies of respondents to the study. One wrote:

> *"A nuclear war is going to require us to be prepared to accept a larger, but uncertain number of refugees ... our responsibility [would be] for all our sisters and brothers",*

while another suggested:

> *"If the economy were unable to provide for the existing New Zealand residents it would be essential to repulse refugees ... I regard this as the most tragic aspect of the dilemma."*

The first view is the humanitarian response that, no matter what the cost or risks, New Zealand should allow unlimited entry to refugees. But would that be fair to other New Zealanders if the numbers were large, if they spread diseases and imposed significant demands on local resources? And even if only a few refugees were to be allowed entry, who would choose and on what basis? Either decision would be difficult to make and to implement if tens of thousands of refugees were to arrive. Because of New Zealand's long stretches of unpopulated coastline, the landing of refugees might be beyond the control of authorities, regardless of the policy at the time.

The responses of neighbouring Asian countries to the arrival of Vietnamese "boat people" in the mid-1970s provides a comparison. The first boatloads of refugees were allowed ashore and accommodated in camps.

Later, when the number of refugees severely strained local resources, ASEAN countries classified boat people as illegal immigrants in order to justify the rejection of new arrivals.[1]

POLICY ISSUES

Despite the uncertainties regarding the number of refugees, there is merit in developing policies based on the likely arrival of refugees in New Zealand after nuclear war. A better understanding of the key vulnerabilities would be a first stage in policy development, since practical issues would assist policy and planning considerations. For example, a particular set of problems is associated with refugees arriving with communicable diseases many months or years after nuclear war. These range from the problems of detecting arrivals outside populated harbours, to requirements for quarantine facilities, needs for medical treatment, food, and shelter. Any policy development should include ethical dimensions as well as practical considerations.

LINKS WITH SOUTH PACIFIC ISLANDS

LOSS OF IMPORTS has been identified as one of New Zealand's major problems if a nuclear war occurred. However, for many Pacific Islands the situation would be worse and there could be a vital role for New Zealand to play in assisting their survival. A primary question is whether a common interest in regional co-operation might exist in the event of nuclear war. Detailed analysis of how individual Pacific Islands might be affected by a nuclear war is an appropriate concern for the countries themselves to consider and New Zealand could provide assistance with such investigations. The following points raise some general concerns.

TRADE AND FOREIGN AID

The South Pacific island economies are heavily dependent on trade and especially imports of food, fuel, medicines, tools and machinery; many things that have become the necessities of life. Their economies also rely on foreign aid, Australia and New Zealand being the major donors. Some countries, especially Western Samoa and Tonga, also depend heavily on remittances from migrants. New Zealand and Australia supply a large proportion of the imported food and medical supplies.

A nuclear war involving Northern Hemisphere countries would leave the Pacific Islands with a limited number of trading partners and New Zealand could take on an increased importance. However, even if New Zealand was *willing* to supply the islands with critical imports (food, fuel, manufactured goods, medicines etc), it might not be *able* to do so. New Zealand might not have sufficient fuel (see Chapter 9), to send ships or aeroplanes with supplies.

With drastically reduced trade, the Pacific Islands would be forced to rely largely on their own resources for food and shelter. Countries with large urban populations and a growing reliance on imported foods would face the greatest disruptions. On the other hand, the Pacific Islands least dependent on foreign imports, are likely to face less disruption.

FOOD PRODUCTION

The Pacific Islands import significant quantities of food at the present time, especially for urban populations. Medium- to large-scale agricultural methods are seldom used to grow food for the domestic market. These methods are mainly used for tropical export crops such as sugar, copra and other vegetable oils. Most export industries rely on imported fertilisers and pesticides to maintain high levels of productivity, consequently many of the Pacific Islands would need to re-orient farming from existing export crops towards crops that could better meet local food needs. Since some local crops take between six and nine months to mature, there could be food shortages and hardship in the interim period.

The Pacific Islands differ widely in their potential for self-reliance in food production, depending on their resources, land area and population density. The "low- islands", or coral atolls (for instance the smallest atolls of Tuvalu) would have trouble feeding their present populations given their dependence on imports. In particular, the small island of Nauru is almost totally dependent on imported food and water.

By contrast, the "high islands" of volcanic material would be less severely affected as they present a wider range of ecological conditions and soil types for food production. Western Samoa, for instance would have plenty of taro, a nutritious food which is currently being exported. However, traditional methods of ocean fishing would need to be revived to replace petrol-powered craft. As with most of the Pacific Islands the majority of the land in Samoa is under some form of traditional tenure

which would allow the rapid re-absorption of kinsfolk, and the *matai* (leadership) system has the capacity to distribute land and other resources in a manner which serves the interests of the group.

Niue represents the intermediate circumstances, in that they grow a lot of their own taro, cassava, yams and sweet potatoes but also import canned goods.

MIGRATION

Over 100,000 Pacific Islanders live in New Zealand and many others visit regularly. Samoans, Cook Islanders, Niueans and Tongans have the largest communities, in Auckland and Wellington. Many are second and third generation residents in New Zealand, with few of the skills necessary for subsistence living in the Islands.

The pressure for migration to or from the Pacific Islands would be strongly influenced by living conditions in those countries and in New Zealand after nuclear war. However, the present free movement of people would be unlikely to continue since fuel supplies would be scarce.

The Pacific Islands could also be vulnerable to the arrival of refugees. Even small numbers could bring about disastrous effects. Refugees could introduce epidemic diseases and, if they were armed, try to appropriate land, food and other resources.

COMMUNICATIONS

After nuclear war, given the many personal links with New Zealand, there would be a strong desire amongst many Pacific Islanders for information about conditions in New Zealand and the fate of their families and friends. Public communication channels with New Zealand would probably become overloaded and so would links between islands. If an EMP disabled New Zealand and Australian communications, the difficulties of re-establishing links between the Pacific Islands would be severe.

Transport to, and between, the Islands, would be reduced to ships, though this would be difficult once fuel supplies ran out since traditional boat-building and navigational skills have been lost from many of the Pacific Islands.

POLICY CONSIDERATIONS FOR THE SOUTH PACIFIC REGION

An important question is the extent of common interest that exists amongst countries of the South Pacific. The success of the South Pacific Forum, the South Pacific Commission and the establishment of the South Pacific Nuclear Free Zone are evidence of regional interests in political, trade and security matters. Would a common interest in co-operation survive nuclear war, or would self-interest dominate? Support for a policy of regional co-operation is more likely if it is considered and planned well in advance of nuclear war or other global upheavals.

The first stage in developing such a plan would be the acceptance by several countries that they share a common interest. This would be based on each country assessing how it would be disrupted by nuclear war and what the advantages of regional co-operation would be (for example, in trade, security, communications, sharing of technology and critical resources).

A New Zealand contribution could start with promoting the idea of national case studies, similar to this study, and with consideration of practical assistance to enable these to be undertaken. The question might also be raised in the South Pacific Forum which could provide the political commitment to develop a work programme to define and examine the major issues. At a minimal level of regional co-operation there is merit in an active programme of information exchange to keep all members of the South Pacific Forum fully informed as to current scientific knowledge of the likely environmental impacts of nuclear war on the region.

There is a need to study how a nuclear war might affect the weather patterns of the South Pacific since changed sea-breeze patterns and reduced rainfall over tropical islands could have serious effects on many Pacific Islands.

Governments could take practical steps to alleviate the worst effects of a major nuclear war by building up and maintaining seed banks of important food crops and other economic plants in national nurseries or in a designated South Pacific "gene bank". Existing agricultural research stations could play an important role in the implementation of crash programmes to enhance the capacity for local food production if food imports were unavailable for an extended period.

POLICY CONSIDERATIONS FOR NEW ZEALAND

The interdependencies between New Zealand and the many South Pacific islands are both complex and varied. These complexities and the absence of information on how different islands would be affected by nuclear war restrict policy considerations to general issues at present. These overlap with the policy issues raised in the previous section, namely the definition and practical expression of common South Pacific interests after global upheavals.

If New Zealand chose to support the concept of a common regional interest after nuclear war there are practical steps that could be taken in support of such a policy. These include the development of contingency plans to maintain or re-establish effective communication links, analysis of transport options given likely fuel shortages, and an agreement on, and definition of, priority needs with specific islands. Such plans might well be disrupted by unpredictable circumstances imposed by nuclear war. However, the planning process may identify a variety of options that could reduce such disruptions and assist recovery.

If it is found that the vulnerabilities identified in this study – such as a lack of self-reliance in pharmaceutical manufacture – apply throughout the South Pacific the argument for region-based planning would be strengthened.

OPTIONS FOR GOVERNMENT: RESPONSES TO CRISIS

"So long as the threats are there we should be indeed foolish if we failed to make plans and preparations against them. For these reasons the Government of New Zealand has decided that appropriate plans and preparations should be made for civil protection in war as well as peace."

W. Anderton, 1959, first New Zealand Minister of Civil Defence

THE INTERACTIONS between all levels of government and the people would markedly influence the character of New Zealand society after nuclear war. The response of the government of the day to the crises imposed by a nuclear war therefore becomes an impact to be examined in its own right.

This chapter first considers the arguments for and against contingency planning. The pressures on central government during the first weeks after nuclear war (the "crisis period") are then elaborated, from which the report concludes that prior planning should improve government's capacity to cope with the multitude of likely problems it would face. Finally, a broader, longer-term issue is identified and discussed, but not resolved. That issue is the role of government during the months and years of painful change and readjustment which the report sees as being quite different from the role of government during the crisis period. More analysis and public debate will be required on this point.

CONTINGENCY PLANNING

Since the report will later argue in favour of contingency planning it is appropriate to first address the philosophical question of whether government should consider undertaking any contingency planning. Such planning would include pre-war actions which could be taken to lessen the impacts of nuclear war (e.g. stockpiling materials, developing greater self-

reliance) and the preparation of strategies for action after nuclear war occurs. Contingency planning is taken to mean improving the chances of survival for society as a whole, not the kind of planning centred on the individual which is commonly found in "survivalist" literature.

The concept of planning now for the aftermath of nuclear war is opposed by some people. They argue that it implies nuclear war is inevitable, engenders despair and makes people less committed to working to prevent war. Some argue that it is futile; others that it implies nuclear war is "survivable", even winnable, and therefore increases the risk of nuclear disaster.

In combatant countries survival planning may have little value given the destructiveness of nuclear weapons and potential "nuclear winter" effects. In the USA, plans for moving people away from targeted areas so as to minimise civilian casualties in a nuclear attack have been discredited by many, both because such plans are impracticable and because they tend to promote the concept of "winnable" nuclear war.[1]

But such arguments against contingency planning do not apply universally. The circumstances of a distant, non-combatant, non-nuclear country such as New Zealand would be very different. Any plans New Zealand made to reduce the disruptions of nuclear war, such as stockpiling essential raw materials and preparing crisis management strategies, would have no effect on the likelihood of nuclear war. The active Swedish and Swiss civil defence programmes have not been blamed for superpower tensions. The Swedes promote both national preparedness and disarmament initiatives, which suggests that both activities can be seen to be in a country's self-interest.

Supporters of contingency planning as a means of reducing post-war disruptions dispute the argument that it implies nuclear war is inevitable. Instead they view contingency planning actions as an insurance policy which they hope will never be used. It provides another reminder of the consequences of nuclear war, and of the value of working for prevention. These views were expressed by many of the people consulted during this study.

In New Zealand no plans for responding to post-nuclear war conditions, or mitigating potential impacts ahead of time, appear to have been developed by government departments or agencies. Perhaps our distance from areas of conflict reduces our perception of the nuclear threat. Yet talks with several department heads during this study revealed a willingness to consider post-nuclear war issues and a recognition of the enormous problems that such a war would cause within government.

The tendency to deal with problems when they arise, rather than plan ahead for uncertain events, is not new. For example, the New Zealand "War Book" (the detailed planning procedures for managing the economy during World War II) was not completed until August 1939, although Britain and other Commonwealth countries had produced their versions several years earlier. A position of having no contingency plans in the event of nuclear war, no stockpiling of strategic materials and equipment, no bolstering of self-reliance in key industries for strategic reasons, does represent a coherent policy. It is a policy that assumes disruptions, trade embargoes, economic collapses, conventional or nuclear war are either a) non-existent threats, or b) would be preceded by sufficient lead-time to allow "appropriate action" to be taken. Other Western countries appear to take a more pessimistic view.

Despite its own considerable reserves of minerals the USA has had a strategy of stockpiling minerals since the early 1950s. US policy is to maintain sufficient stocks of 94 minerals to supply US industry for up to three years.[2] In 1982 the stockpile was worth over $12,000 million. Other Western governments, including France, Britain, Japan, Sweden, Italy and Spain already have, or are developing, strategic stockpiles of important minerals as a precaution against disruption of supply.

By contrast, New Zealand governments have shown little inclination to sustain similar policies. For example, following the oil price rises of the 1970s a National Strategic Petroleum Reserve was established but the last stocks it held (48,000 tonnes of diesel) were sold in January 1987. The government cited "little reason for continued investment"[3] as the justification for the sale which attracted little public comment.

As the NRB poll referred to earlier made clear, the public favour planning to help cope with the aftermath of nuclear war. The sentiments expressed by W. Anderton in 1959 may not have found a practical expression in the subsequent development of the Ministry of Civil Defence, but they continue to have public support.

RESPONSES DURING THE CRISIS PERIOD

With the news that nuclear war was imminent or had begun, people would focus very strongly on their personal, family and community needs, but they would probably look to government for assurance that those needs would be met.

People would expect official information about what had happened and what would be likely to happen. Should they expect bombs on New Zealand? How could they tell what radiation was being received? What was happening in Australia and in Pacific Island countries? Should they expect an invasion by military forces, or the arrival of refugees? How could they communicate with or travel to family members? When would the telephone system cope? Was there enough petrol for them to travel? What food was safe? What household supplies were likely to be scarce? What was likely to happen to their cash in the bank, their property, their wealth? Would their employer continue to pay wages?

The ability of central government to answer all these questions could be in doubt. Disasters and crises affect not only individuals, but also the behaviour and functioning of organisations. This is often overlooked in disaster planning (Chapter 5) and can be overlooked when considering the likely impacts on government. The focus here is on central government decision-makers (Parliament, and especially Cabinet in the event of a national crisis), advisors to decision-makers (senior public servants) and staff in government departments. People in all three categories have specific roles to play in the successful resolution of crises. Co-ordination between them would be essential if effective decisions were to be made and implemented during the first weeks after a nuclear war.

The ability of decision-makers and their advisors to exercise good judgement can be lowered by high levels of crisis-induced stress. There are several historical examples of the damaging impacts of such stress on national leaders. Theodore Sorensen observed President Kennedy's advisors during the Cuban missile crisis, and noted "during the long days and nights of the Cuban crisis, how brutally physical and mental fatigue can numb the good sense as well as the senses of normally articulate men".[4]

After a nuclear war New Zealand decision-makers would be facing much greater stresses. As well as their national responsibilities they would have to cope with the same fears and recognition of personal losses as everyone else. The suddenness of crises, the need for quick decisions, the lack of information, and the cumulative strain would cause enormous stress. The outcome could be hastily-made decisions without adequate analysis or consultation, and an over-reliance on personal beliefs or inappropriate historical precedents to resolve issues of unprecedented complexity.

How might government respond upon learning that nuclear war had occurred? The report speculates below on the first few actions that might be taken as a way of illustrating the demands and constraints on government during the first few days.

If circumstances permitted, Cabinet would probably meet immediately and proclaim a national emergency. The Civil Defence Act 1983 could be used for this purpose as it has provision for proclaiming a national emergency and confers wide powers "for the purpose of securing the public safety" (Clause 79). The Civil Defence network has a role to play in crisis management, but the extent to which government would and could rely on it after nuclear war is not clear.

As soon as possible the Prime Minister would probably make a public broadcast on national radio and television to inform the people of the actions government had taken, describe the situation as it was known, give assurances of the continuity of government, appeal for calm and respect for law and order, undertake to be open with regard to information, and request co-operation of local authorities and the private sector.

The need to keep the public fully informed of all relevant information should be a high priority despite other demands on decision-makers, especially during this period of great uncertainty (see Chapter 5). Nationwide broadcasts would require operational communication systems. In the event of an EMP, the ability of the government to communicate, both internally and with the public, would be severely limited. What methods it would have available to overcome these problems remain to be investigated.

To assist it with decision-making, government might then form an Emergency Cabinet which could include department heads, representatives from opposition parties and leaders from the private sector. Over the following weeks this cabinet would be expected to respond to the following concerns.

Police, Defence, Foreign Affairs and other key departments would be looking to the Emergency Cabinet for instructions. The financial sector would be in a state of great uncertainty. Pressure to ration petrol, diesel and other essential supplies would be high, although there could be conflicting advice and demands over how to set priorities and determine rationing systems. The establishment of adequate food distribution systems and ensuring that people obtained basic necessities would be a high priority for officials. There would be public demands for accurate monitoring of radia-

tion levels and information on what should be done to prevent contamination by fallout. Contingency plans for a possible influx of refugees would be needed. Health professionals would want procedures for conserving remaining stocks of pharmaceuticals.

If the present lack of preparedness were to apply, then these decisions and many others would be difficult to make, let alone to implement. If effective communications or consultation were not maintained the difficulties could prove impossible for a centralised decision-making system to handle.

GOVERNMENT ROLES AFTER THE CRISIS PERIOD

Assuming government and the country survived the initial few weeks without social collapse, what then? Would the ongoing hardships, unemployment, and piecemeal readjustments lead to civil unrest, social breakdown and repressive government responses? A number of respondents to this study believed this was a likely outcome and advanced the argument that the continuity of central government was paramount. They felt that government would need to resort to "strong measures" and draconian laws to stay in power, and that without such control there would be rapid social breakdown. The implication was that without centralised control, New Zealanders would respond from motives of self-preservation and social conventions would soon break down. From this perspective the worst outcome would be the breakdown of central authority, and therefore government planning for post-nuclear New Zealand should start from the premise that its major objective would be to maintain its authority and capacity to direct people's lives.

Other respondents took a more positive view of human nature in times of crisis. They suggested that rather than the government confronting the populace to maintain power and control, the circumstances of post-nuclear war New Zealand would force both government and people to develop more co-operative structures to survive. These respondents saw a potential role for existing organisations, citizen networks, and community leaders in providing leadership and cohesion.

Neither group had the benefit of knowing how nuclear war was likely to affect the basic systems which sustain New Zealand society. Perhaps with the knowledge contained in this study they may change their views of the likely outcome for society and the appropriate role of government.

But even with the benefit of these insights it is not sensible to suggest one outcome or the other. In truth, many different outcomes would be possible. That in itself is the point that is often overlooked. Barring a successful military invasion, the shape of New Zealand society after nuclear war would be determined by the people within the constraints of resources.

The important issue to address is not whether central government *could* retain power and control but whether it *should* and for what reasons. Central government was felt to have major responsibilities during an initial crisis period. Once that period had passed the problems would change however and new responses would be called for. Whether central government structures would be the most appropriate mechanism for assisting the long-term readjustments will require further analysis.

A useful indication as to what role government would be most likely to play would emerge from an analysis of how decision-making in post-nuclear war New Zealand would be handled. Three issues that would require resolution are: determining the rules for access to resources (e.g. medicines, petrol) and the basis for resource use; enforcement of those rules and control of resources; development of mechanisms for integrating specific groups into decision-making/implementation processes (e.g. unions, employers, manufacturers).

What government could and should do would in fact depend largely on post-nuclear war conditions. Different analyses will clearly apply for scenarios with or without an EMP effect. Many of the outcomes summarised in earlier chapters indicated that restriction of activity to local and regional levels would be probable, forced by overall reduction in economic activity, loss of export and import trade, and constraints on transport fuels. A provincial government structure would be a more appropriate mechanism than today's central government structure for coping with the multitude of problems.

POLICY ISSUES

The choice between centralised and non-centralised approaches raises substantive and important issues that go well beyond the scope of this preliminary inquiry. The viability of regional structures with stronger local government, in co-operation with local branches of state agencies, business and community organisations needs to be investigated. The premises on which decision-making and power are shared between people and govern-

ment systems should be evaluated for a variety of post-war circumstances. In the event of communications being seriously disrupted central government could rapidly become ineffective and non-centralised responses are likely to be the only viable options.

Crisis management under extreme stress without contingency plans for guidance is a dangerous position for any organisation. Yet that is the condition any New Zealand government would be in if nuclear war were to occur in the near future.

A systematic review of planning systems is needed to investigate the issues raised in this chapter. Such review and the subsequent development of contingency measures are justified given the unprecedented situations New Zealand would face after nuclear war. Even though the likelihood of nuclear war is low, the fact that it is possible at all justifies contingency planning, given the consequences if it happens. It is too late to develop procedures for crisis management once the event occurs.

While the initial impetus for establishing this public planning process could be the responsibility of further independent investigation (see Chapter 17), a more permanent planning structure may be needed. Plans would need updating as new information became available. The merits of establishing a small unit with ongoing educative, contingency planning, monitoring and co-ordinating functions, should be considered. Particular care should be taken to prevent the review of planning systems from being captured by traditional bureaucratic approaches. One central element would be a high degree of public involvement. Both public insights and ideas as well as public co-operation and acceptance would be essential to its success. The objectives would be more wide-ranging than the production of instruction manuals. They would include strategies for responding to issues in the crisis period and for the longer-term problems that would follow. Widespread public debate of these longer-term issues is especially important and should form part of the follow-up to this report.

CONCLUSIONS

SUMMARY

A major nuclear war would kill hundreds of millions of people through blast, radiation, disease and starvation. These effects would be felt principally in the Northern Hemisphere where there are the biggest population centres, the major likely combatant countries and most of the likely targets for nuclear weapons.

The effects on New Zealand would be devastating, but different from those experienced in the north. New Zealand is not likely to be a direct target nor suffer direct effects. Radioactive fallout would not be a major threat to health in New Zealand: it might add 1% to the normal incidence of cancers over the following 70 years. New Zealand would not suffer the extreme nuclear winter effects expected in the Northern Hemisphere: crop losses would occur, but probably not to the extent that people would starve.

However, even without direct physical impacts, a major nuclear war would fundamentally disrupt New Zealand society. The effects would be widespread, some sudden, some longer lasting. There would be immediate fear, if not panic, at the possibility of direct targeting of nuclear weapons on New Zealand and of radioactive fallout. There would be for everyone a massive sense of grief and the pervasive psychological effects of loss of contact and isolation. The most serious longer-term effects would be caused by the loss of imported supplies on which every sector of activity in New Zealand depends and the loss of markets for export production which shapes much of the social and economic structure of the country.

It is not possible to predict whether society would hold together or tear apart: that would depend heavily on how well prepared New Zealanders were and how they responded to the enormous trauma and disruption. It is unrealistic to expect that the response could ever be calm and well-organised. Along with the realisation that nuclear war had occurred and the immediate shock and fear, there would be the growing realisation that people could no longer rely on structures and systems now taken for granted.

Central government would be under intense pressure during the initial weeks of crisis. People's demand for information and direction would be high, while government would be forced into rapid decisions on many urgent issues. Without prior contingency planning these difficulties could prove insurmountable. (In the months and years after a nuclear war the nature of government structures and decision-making might change considerably. Devolution of power to regional or community levels could be the most viable and appropriate option.) Some of the impacts that would shape post-nuclear society are summarised below. Health care in New Zealand is virtually 100% dependent on imported medicines, vaccines, and medical and dental supplies. Stocks on hand would suddenly become the only reliable source. Medicines could be rationed and supplies eked out for a year, or perhaps two. But if local alternatives were not developed rapidly a tremendous increase could be expected in diseases and illnesses now controlled by drugs. Refugees could bring new sources of infection. Water supply and waste disposal systems would be at risk from the loss of imported chemicals and spare parts. The energy and transport services on which those systems rely would similarly be at risk from the loss of imported fuels and spares. A computer system failure could close New Zealand's single oil refinery and reduce diesel supplies to zero. This in turn would cripple coastal shipping and ferries, diesel locomotives, much road transport, some manufacturing and food processing industries. The loss of these diverse systems would then create additional problems in many other areas.

Loss of export markets and of imported supplies, components and spares would make existing patterns of farming and forestry irrelevant, or unsustainable. This would cause major disruptions to asset values and prices, to employment and to wage and salary incomes. Shops, banks and other financial institutions would be affected by those disruptions as well as failures in their own internal systems.

In many cases the effects would not be immediate: stocks of imported items would be available and many early breakdowns could be fixed. But it would soon be apparent that the failure of major facilities and systems, such as the synthetic petrol plant, the refinery, power stations and the Cook Strait cable, would be inevitable over coming months or years.

These failures would be sudden and comprehensive if New Zealand were affected by an electromagnetic pulse (EMP). New Zealand's strategic insignificance means there is little likelihood of it being a deliberate target for an EMP. But the growing militarisation of space and the importance of the Australian communications facilities do increase the possibility of New Zealand becoming an indirect target. The likelihood of an EMP affecting New Zealand is lower than the probability of nuclear war but the consequences would be devastating. Communication, energy, banking and transport systems would be crippled instantly with no time to develop alternative systems. An EMP could well mark the end of present social and economic structures and force people into subsistence living.

In reviewing the overall findings of this study, four main interrelated points should be noted. These are the extent of New Zealand's dependence on international trade, the increasing vulnerability of the technologies used in key systems, the strong interdependency between sectors, and the lack of contingency planning.

Imports provide vital materials and spares for most activities in New Zealand; exports are the predominant outlet for major primary industries on which depend, directly or indirectly the jobs and incomes of hundreds of thousands of New Zealanders. Disruption of trade following a nuclear war would dislocate the lives and wellbeing of all New Zealanders.

Technologies used now in sectors supplying basic needs such as communications, energy, transport and health are very vulnerable to the loss of imports and to an inability to repair, replace parts or manufacture substitutes solely from local resources. In addition there is a continuing loss of the skills, knowledge and equipment of older technologies which could be serviced and manufactured locally.

Strong interdependence between sectors means that vulnerability in one sector produces vulnerability in others. Conversely, reducing vulnerability in one enhances its reduction in others. The health system depends on trade, energy and transport. The sub-sectors of energy are deeply dependent on one another and on transport and communications. No sector or system stands alone.

After nuclear war extremely difficult decisions would need to be made to set priorities, conserve stocks and develop alternative systems. Contingency planning could help in this process but at present there is no planning within or outside government for responding to the impact of nuclear war.

As noted earlier, while the direct impacts on New Zealand would be relatively minor, the overall effect would depend crucially on how well prepared New Zealanders were. At present New Zealanders are ill-informed and ill-prepared.

WHAT TO DO

The highest priority in the face of the threat of nuclear war must always be given to prevention. Although New Zealand would be among the countries least severely affected by nuclear war, the effects here would still be catastrophic. For our own sake as well as out of concern for the rest of humanity it is important to find and pursue the policies that will be most effective in preventing nuclear war.

But even the best strategies for prevention may fail. Nuclear war is not inevitable but it is possible. What is it worth doing in preparation in case prevention fails?

Faced with relatively unlikely but disastrous possibilities, people do take precautions individually and collectively – such as paying for fire insurance, conducting civil defence exercises and strengthening buildings against major earthquakes. What they are prepared to do depends on a combination of the probability of the disaster occurring and the cost of preparation compared with the cost of not being prepared if disaster did occur. Similar considerations apply in the case of the threat of nuclear war.

This study was asked to assess the likely impacts on New Zealand of nuclear war and make recommendations for more detailed second phase studies to resolve important issues of uncertainty. Three categories of follow-up programmes should be considered:

- improving public knowledge of the likely impacts on New Zealand of a nuclear war;
- drawing up contingency plans for action if war occurred; and
- taking action now to reduce vulnerability to the effects of nuclear war.

Improved public knowledge of the consequences of nuclear war for New Zealand is an essential first step. It is needed as the basis on which people decide how much effort to put into preventing nuclear war and to preparing for it.

Because most of the information available now relates to what is likely to happen in Northern Hemisphere countries it is particularly important to provide better information about the very different effects likely to be felt in New Zealand.

The authors hope that this report will make a useful contribution to better public knowledge. The report does not claim to be definitive: critical discussion of it will identify where fact and interpretation can be improved. There are many areas where more research would be useful; some concerning New Zealand alone are mentioned in the later discussion of contingency planning. Two are more international in character.

Better information is needed about the climatic effects in the Southern Hemisphere of nuclear war. Closer regional co-operation between scientists in Australia, New Zealand and the Pacific Islands could ensure that improved information from Northern Hemisphere research programmes is monitored and that the necessary studies are carried out to adapt and interpret their results for Southern Hemisphere countries.

This study has wide international relevance for studies of the consequences of nuclear war. As a remote food-exporting nation New Zealand is more likely than most countries to survive nuclear war relatively unscathed. However, this study found that physical survival would not guarantee social survival and that without northern trade, collapse of New Zealand economic and social systems is possible. If this is a credible outcome for New Zealand, how might other non-combatant countries fare? Studies carried out in other countries along similar lines would add further understanding of the impacts of nuclear war on the global community.

While research is necessary it must be stressed that making the results available and accessible to the general public is vitally important. It is not just government officials and scientists who are affected by the threat of nuclear war. General understanding of what is likely to happen if nuclear war occurs allows an informed public debate which is necessary both for effective prevention and for effective responses if prevention fails.

Contingency plans for key sectors and systems would play a major role in reducing uncertainty and disruption if nuclear war occurred. The pro-

cess of preparing them would also improve our knowledge of the impacts of nuclear war and identify areas where more research would be worthwhile.

Previous chapters identify where contingency plans could be developed now. For example: a plan for central government should set out the major decisions to be made, the methods of communication government would use, and the extent to which it should rely on central direction or the devolution of power to regional or community agencies.

In the health sector, agreement is needed on plans for managing limited stocks of medicines and for maintaining preventive public health systems. The feasibility of producing human medicines in New Zealand should be studied to identify present barriers to production and whether production could begin quickly following the loss of current sources of supply.

For the financial and monetary system, a set of procedures should be agreed for maintaining or replacing electronic systems, guaranteeing deposits, maintaining adequate cash for people's needs and adjusting assets and liabilities in an orderly fashion. This should reduce the danger of sudden collapse in the financial system and retain a capacity to assist rather than impede adjustments in production, employment and consumer demand.

Similar contingency plans should be given priority in communications, energy and transport, and in sectors not examined in this study.

Two important points should be noted. The public exchange of information adds a vitally important dimension: plans drawn up and kept internally by government or by individual sectors would be less useful than plans developed through a public process and exchanged between sectors. Without wide public support, contingency plans would be of little value. Secondly, the preparation of contingency plans for a possible future event like a nuclear war can be useful now by identifying weaknesses in current practices. For example, is it only cost that prevents the production of medicines in New Zealand? To what extent does present use of local energy resources take account of uncertainty in future supply?

Vulnerability to the effects of nuclear war cannot be eliminated. It arises not just from dependence on a few strategic imports: it flows from all ties to the rest of the world. But key areas of vulnerability can be identified and the options and costs of improving self-reliance examined. This study has identified some obvious candidates for closer examination. Among medical supplies there may be some which could easily be produced locally and

others where the costs of domestic production would be very high. In communications and computer technologies there will be choices between hardening against EMP effects, installing back-up systems, or retaining the capacity to resort to simpler technologies. Stockpiling trace elements for agriculture and promoting a variety of recycling industries are examples of other options for reducing vulnerability to the loss of imports.

The overall purpose of continuing this study of the impacts of nuclear war into a second phase should be to advance from research on the consequences of nuclear war into an active public information programme and into contingency planning where the public is effectively involved in deciding what risks should be accepted and what price should be paid for reducing risks.

Responsibility for these diverse public information, research and contingency planning activities in different sectors should not be given to one agency. Much of the work needs to be done within existing public and private sector agencies. However, to initiate, organise and co-ordinate this second phase programme, a specialist unit should be set up and funded for a limited establishment period. At the end of that time full responsibility for ongoing work should return to the agencies most directly concerned. The specialist unit could prepare material for public information, co-ordinate continuing scientific investigation, initiate the development of contingency plans and investigate the feasibility of reducing import vulnerabilities.

Above all, it is important that the second phase of this project be paralleled by continuing public discussion about the part New Zealand can play in nuclear war prevention strategies. For while survival may be preferable to death, life without the nuclear threat will *always* be the most important goal.

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PUBLIC OPINION SURVEY

AS PART OF THE NUCLEAR IMPACT STUDY, a market research firm, AGB:McNair was commissioned to establish the depth of knowledge and beliefs held by the New Zealand public as to the most serious consequences for New Zealand following a nuclear war.

Two questions relating to New Zealand after a nuclear war were included in an AGB:McNair Omnibus survey, which was based on a random sample of 1,137 people selected to represent the New Zealand population.

For the first question (which was unprompted) respondents were given the following scenario:

> *Imagine there has been a major nuclear war and most of the nuclear targets have been in the Northern Hemisphere. New Zealand has not been hit by any nuclear bombs.*

and were then asked:

> *Under these circumstances what do you think would be the serious consequences for New Zealand as a whole? What others?*

The following table gives the responses, grouped into categories, of the consequences people gave (the percentage base was weighted down to 1,101). Percentages total more than 100 since people gave more than one consequence in their replies.

CONSEQUENCES	*PERCENTAGE BASE = 1101*
Food/crops	25
Radioactive fallout/radiation	22
Trade loss	21
Colder weather/'nuclear winter'	19
Refugees/overpopulation	12
Disease/sickness	11
Change in atmosphere	10
Isolation	9
Death from radiation	8
Environmental contamination	8
Death – General	7
Resources/supplies	6
Economic disaster	5
The end of everything	4
Haven't thought/try not to	4
Breakdown in law and order	4
Lack of medical supplies	4
Breakdown in society	2
General chaos	2
Threat of war etc	2
No outside news	2
Effect on people/suicide	2
Don't believe it will happen	1
Other	7
None/No effect	2
Don't know/Not specified	8

Although direct mention of radioactive fallout/radiation was mentioned by 22%, the percentage was in fact higher, since a proportion of the replies in the categories of "disease/sickness", "death from radiation" and "environmental contamination" contain references to radiation.

For the second question, people were then told:

Here is a card which lists some possible consequences in New Zealand of a major nuclear war in the Northern Hemisphere.

and asked:

a) *Which one would you suggest as the most serious for New Zealand as a whole?*

b) *Which one would be the second most serious?*

c) *Which one would be the third most serious?*

The following table gives the responses, as percentages, of people's choices for the most serious consequence. There were no significant differences in sex and ethnic origin with respect to the most serious consequence they gave, and few in terms of age.

MOST SERIOUS CONSEQUENCE	*PERCENTAGE BASE = 1101 (100%)*
Radioactive fallout/radiation	46
Colder weather ('nuclear winter')	11
Not enough food	7
Shortage of medical supplies/drugs	6
Refugees coming in from overseas	6
Breakdown in law and order	6
Disruption to the economy	4
Loss of trade with other countries	4
More disease	2
More mental breakdown and suicide	2
Lack of information from overseas	2
Transport problems	0
Don't know/refused	4

When all the consquences mentioned as being serious were analysed in combination (whereby those given as the most serious consequence were multiplied by a factor of 3 to reflect their importance, those given as the second most serious consequence were multiplied by 2 and those given as third most serious were multiplied by a factor of 1), radioactive fallout/radiation was still perceived as being the most serious consequence for New Zealand.

The following table shows the relative importance of the consequences.

CONSEQUENCES	*PERCENTAGE (of potential maximum score achievable)*
Radioactive fallout/radiation	57
Colder weather ('nuclear winter')	23
Not enough food	23
Shortage of medical supplies/drugs	18
Breakdown in law and order	14
Refugees from overseas	12
Loss of trade with other countries	11
Disruption to the economy	11
More disease	10
More mental breakdown and suicide	5
Lack of information from overseas	4
Transport problems	1

It is curious to note some of the topics that were not specifically mentioned, which in fact the Nuclear Impact Study found *would* be a problem for post-nuclear war New Zealand, that is: transport, loss of fuels, communication problems, and loss of jobs through the loss of export markets or imports.

BACKGROUND PAPERS

THE FOLLOWING PAPERS, containing detailed background information from which most of this report was written, are available from the publishers, The New Zealand Planning Council, PO Box 5066, Wellington.

1a The likelihood of nuclear war
1b Study assumptions
2 Impacts on New Zealand's climate and growing season
3 Impacts on New Zealand's natural environment
4 Meeting New Zealand's food needs
5 Effects of electromagnetic pulse on power and communications
6 Impacts on energy systems in New Zealand
7 Impacts on communications systems in New Zealand
8 Disruptions to transport systems in New Zealand
9 Radiation effects on the environment and people
10 Impacts on health and the health care system in New Zealand
11 Human responses to disaster - a review
12 The impact on New Zealand society
13 Impacts on New Zealand's urban systems
14 Government agencies for control and recovery in New Zealand
15 Policy options and planning approaches for the NZ government
16 Initial impacts on New Zealand's financial sector
17 Initial disruptions to trade and employment in New Zealand
18 International migration to New Zealand
19 Implications for links with South Pacific countries